POWER PLANT ENGINEERING

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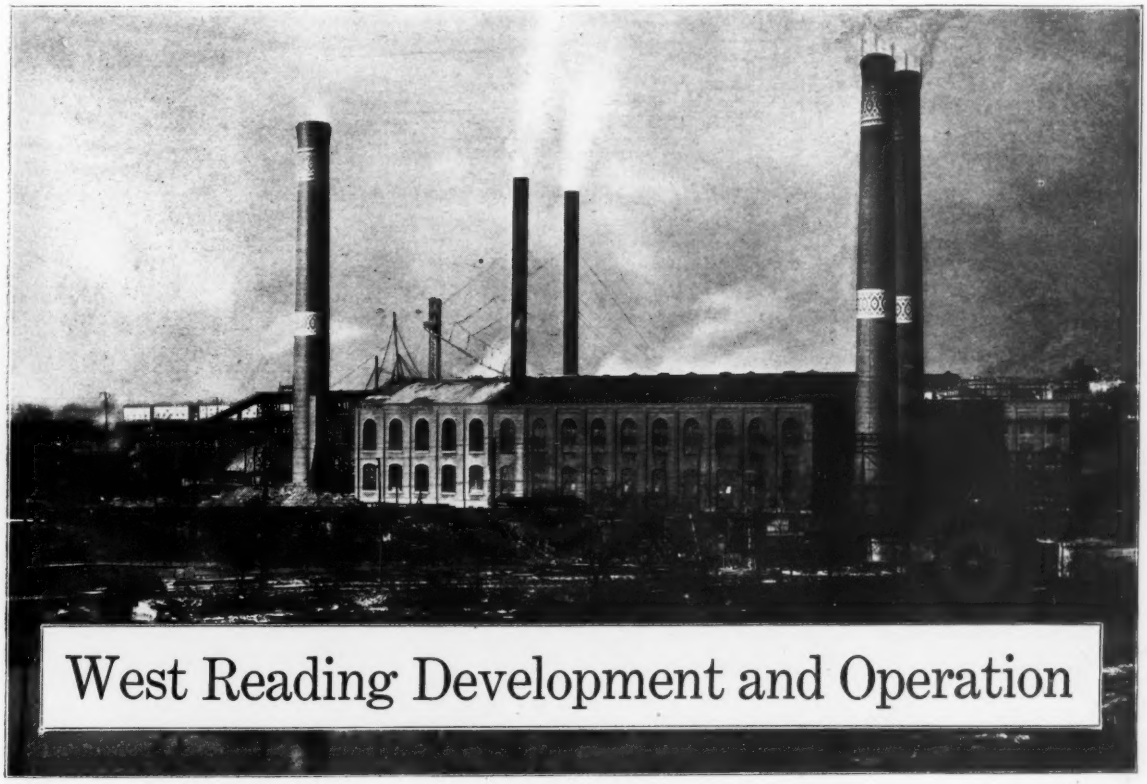


West Reading Development and Operation

REQUIREMENTS OF CONTINUITY OF SERVICE AND RAPID INCREASE OF LOAD HAVE REQUIRED ADDITIONAL EQUIPMENT AND CAREFUL MANAGEMENT

SITUATED in a district where the estimated value of the manufactured products has increased 400 per cent within a period of 5 yr., is the West Reading (Pennsylvania) plant of the Metropolitan Edison Power System. The demand for power has increased during the same period in a like proportion to manufacturing products such that the installed generating capacity at this plant has been increased from 13,500 kw. in 1916 to about 71,500 kw.

Tied in on the system with West Reading are other generating stations, the larger ones of which are located at Dover, Easton and York Haven, Pa. In addition there is now being constructed at Middletown, Pa., a station, the first units of which will consist of a 37,500-kv.a. General Electric turbo-generator and five 1500-hp. Connelly boilers. These boilers will be fired with pulverized bituminous fuel and powdered river coal, the latter will be reclaimed at a low cost per ton by a fleet of company boats operating on the Susquehanna River. An interesting feature of the fuel burning installation is that ratings of 300 per cent will be expected with either pulverized anthracite or bituminous coal.

Service required from the West Reading plant is greatly diversified, as will be understood from the fact that Reading has been classified as second among the cities of Pennsylvania for the greatest diversity of industry, being excelled only by Philadelphia.

Present boiler equipment at the West Reading station consists of sixteen 575 hp. four pass Edge Moor boilers equipped with seven-retort Taylor stokers, and two 1000 hp. three pass Edge Moor boilers equipped with eleven-retort Westinghouse stokers. These boilers generate steam at 200 lb. pressure and 100 deg. F. superheat. The generating equipment consists of one 25,000 kv.a. Westinghouse turbo-generator, one 12,500 kv.a. General Electric turbo-generator and two 4500 kv.a. Allis-Chalmers turbo-generators; also one 4500 kv.a. Allis-Chalmers synchronous condenser. This condenser was the

generator of a third 4500 kv.a. unit, the turbine having wrecked itself to such an extent that it was impractical to be repaired.

The two steel stacks shown in the head piece are temporary and another brick stack is now being erected near the point at which the coal conveyor enters the building.

Additions Being Made

There are being installed at the West Reading plant at the present time six 1000-hp, Edge Moor boilers, three of which will be equipped with Taylor stokers, and three with Westinghouse stokers; and in the turbine room will be added a 37,500-kv.a. unit equipped with a surface condenser. At present the 12,500 and 25,000 kv.a. turbines are equipped with low level jet condensers while the smaller units are equipped with barometric condensers. Practically all auxiliaries are driven by steam. Condensing water is taken from the Schuylkill River, where, due to the shifting river bottom, it has been found necessary to keep a dredge operating for about 2 mo. out of each year in order to keep the intake free of river sediment.

Working pressure on the new 1000-hp. boilers will be 285 lb. or about 85 lb. higher than that carried by the old boilers. Present plans do not provide for operating the high and low pressure headers as one system; instead, the plant will be operated as two units, one at 200 lb. pressure and the other at the higher pressure. This means that the new turbo-generator will operate on the high pressure side. Feed water is obtained at present from the Wyomissing Creek, which has been turned from its natural course and runs into a dam from which it is piped about one-half mile to the plant. The harder tributaries to this stream have been bypassed so that they enter the main stream bed a short distance below the dam.

All Feed Water Is Treated

With the jet type of condenser, it is apparent at once that the feed water for the old units is 100 per cent make up and must all be treated. All new auxiliaries will be motor driven and the condensate from the surface condenser will be used as condensing water for the steam from the old auxiliaries, which will be driven at the 200-lb. pressure. The condenser which will be provided for this purpose will be of the barometric type. The condensed auxiliary steam, which has in fact gone through an evaporation process is, therefore, mixed with the condensate from the surface condenser; in other words, the condensed auxiliary steam will constitute the make up for the high-pressure boilers. Feed water treatment will not be required then for the high pressure part of the plant, although treatment for the present portion of the plant will continue to be practiced as at present.

Current is generated at present at 13,200 v. and is taken direct to an outdoor substation located near the plant. Oil from any of the switch and transformer casings may be drained directly into an underground tank provided for this purpose; this overcomes the nuisance

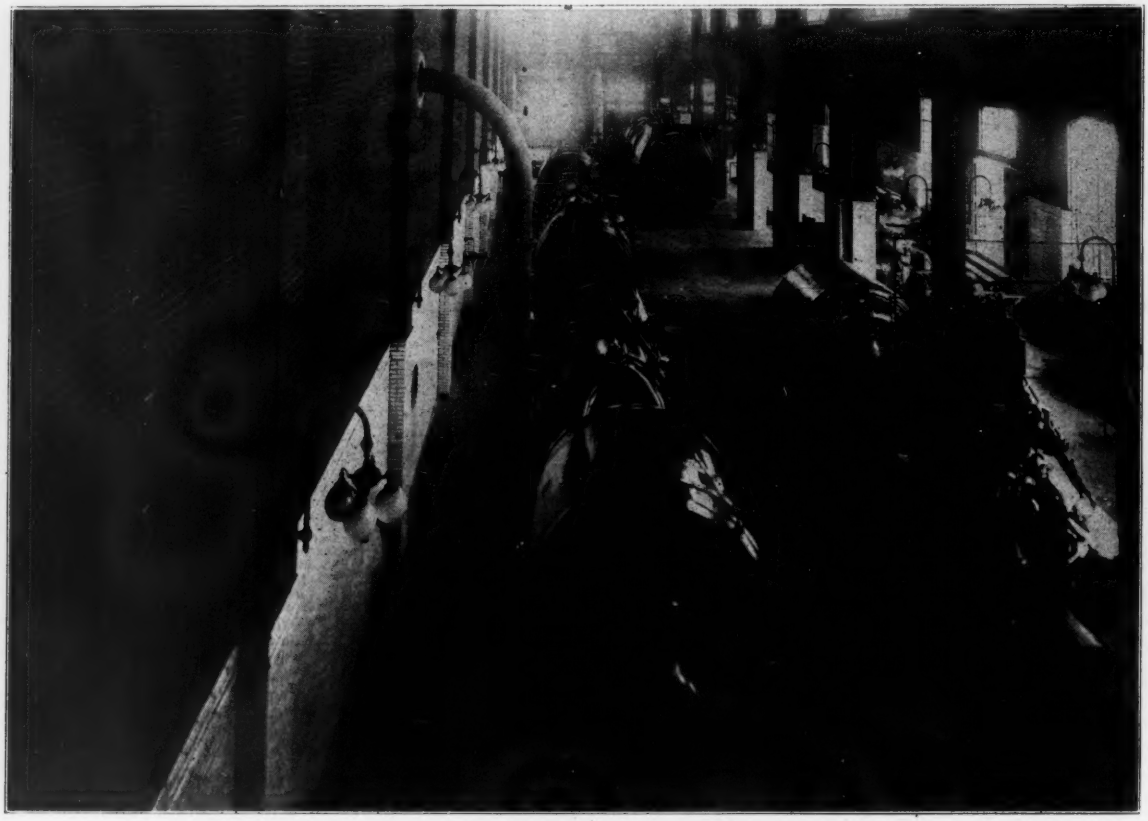


FIG. 1. GENERAL VIEW OF TURBINE ROOM AS AT PRESENT. NEW 37,500-KV.A. UNIT WILL BE ERECTED AT THE FAR END OF THIS ROOM

of having a great many receiving barrels on hand when a change of oil is necessary. From the plant substation current is carried at 13,200 v. to a substation just outside of the city limits where it is stepped up to 110,000 v. and cut in on the transmission lines which form a part of the tie-in and distribution system of this company.

West Reading plant is well situated with regard to coal mines, and is served by two railroad systems. The coal storage yard has a capacity of 20,000 T. and is served by an elevated track which is arranged so that coal may be unloaded directly from railroad cars into a 250-T. receiving hopper, or it may be unloaded on either side of this hopper for storage in other parts of the yard. Crushing equipment is located under the hopper. The crushed coal is picked up from the crusher by a 1600-ft. belt conveyor, carried up an incline and distributed in overhead bunkers for distribution to the stoker hoppers. Coal which is not required for immediate consumption is rehandled by a system of portable belt and bucket conveyors.

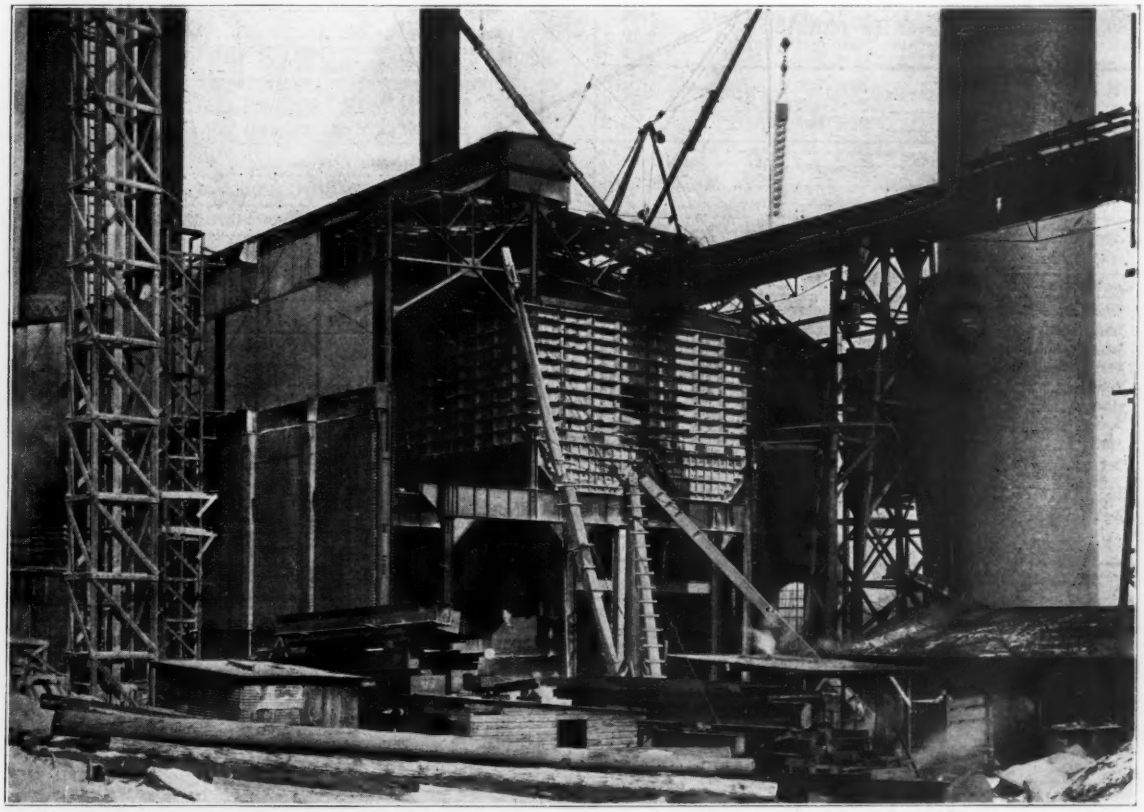


FIG. 2. ERECTION OF THE NEW BOILERS IS WELL UNDER WAY. THE GUYED STEEL STACKS ARE TEMPORARY

As each carload of coal is stored a 500-lb. sample is taken from which a laboratory sample is made up and record is made on form shown in Fig. 4 of just where that carload was placed. Due to the relatively large number of mines from which coal is purchased, it has been found that there is quite a wide range in quality. By this storage charting system it is possible to reclaim the coal, as it will best serve conditions in the plant; that is, during severe service demands only the better coal need be reclaimed. To reclaim the coal, a 7-T. car has been provided, by means of which coal is transported from the storage yard to the yard hopper.

Coal Shipments Controlled

To facilitate the follow-up of coal shipments, a board has been constructed on which is painted a map showing the location of the power plant, the various coal mines, and the system of railroads over which coal is shipped and received. Colored pegs are used to designate the various mines and as coal is shipped or moved the information is spotted on this board. This further serves as a means by which the grade of coal which is to be received in the immediate future may be anticipated.

All coal is purchased on the basis of an ash content of 8 per cent. If the ash content runs above this value, the mine is penalized; if it runs less than that amount, the mine is paid a premium. It is provided by contract that the expense of sampling and analyzing the coal is to be borne by the Metropolitan Edison Co., and that the mine is to accept this analysis as final. Coal delivered to each boiler is recorded each hour as shown by stoker counters. The total coal to each boiler is weighed by automatic scales and the record for a given period entered on the chart shown in Fig. 6. As an index to the economy obtained, a chart is made up at the end of each month which classifies the coal received as to the per cent ash and volatile matter which it contained; in this manner, a falling off or

increase in boiler efficiency can be in part accounted for.

Testing Bureau Laboratory

All tests for the West Reading Plant are taken care of by the testing bureau laboratory. The equipment of this laboratory is unusually complete and the work performed is not alone along purely analytical lines,

METROPOLITAN EDISON COMPANY
TESTING BUREAU LABORATORY
READING, PA.

CERTIFICATE OF DRINKING WATER ANALYSIS

Water Sample From ..... Date Taken ..... M.
Address ..... Date Received ..... M.
Source ..... Date Completed ..... M.

Appearance .....
Sediment .....
Color .....

Bacteriological Examination Incubated for 48 Hours at 37°	Positive	Negative
Bacteria of the B-Coli Type		
Tubes ... c.c. Inoculation Lactose Peptone Bile		
Tubes ... c.c. Inoculation Lactose Peptone Bile		
Tubes ... c.c. Inoculation Lactose Peptone Bile		
Tubes ... c.c. Inoculation Lactose Peptone Bile		
Plate ... Agar ... Colonies		
Plate ... Agar ... Colonies		
Plate ... Agar ... Colonies		
Plate ... Agar ... Colonies		
Plate ... Agar ...		
Plate ... Agar ...		

Sanitary Analysis as Parts per Hundred Thousand	
Quantitative Tests	
Acidity	
Alkalinity	
Causticity	
Chlorine	
Permanent Hardness	
Temporary Hardness	
Total Hardness	

Remarks:-

FIG. 3. COMPLETE ANALYSIS IS MADE THREE TIMES EACH WEEK OF THE DRINKING WATER

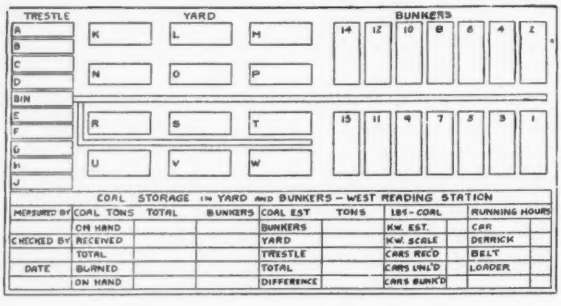


FIG. 4. ALL STORED COAL IS CHARTED SO THAT IT MAY BE RECLAIMED IN ACCORDANCE WITH ITS QUALITY

but is closely allied and directly tied in with certain details of plant operation. Besides the coal analysis already referred to, this laboratory analyzes the coal and oil for all other plants in the company. It also runs tests once a month on the oil used in each main unit; and stream flow and weather reports are also submitted to the State and U. S. Governments.

Complete analysis is made three times each week of the drinking water supply; this water, incidentally,

METROPOLITAN EDISON COMPANY
TESTING BUREAU LABORATORY
READING, PA.

ANALYSIS OF COAL AS RECEIVED

Name of Company .....
Name of Mine .....
Car Number .....
Date Sample Taken .....
Date Sample Received .....
Date Sample Analyzed .....
Analyzed by .....

Weight of Crucible Plus Sample	
Weight Minus Moisture	
Wt. Minus F. C., V. M., Moisture	
Weight of Crucible Plus Sample	
Wt. Minus Volatile Matter and Moisture	

RESULTS OF ANALYSIS

Per Cent. Moisture	
Per Cent. Volatile Matter	
Per Cent. Fixed Carbon	
Per Cent. Ash	
B. t. u. by Analysis	
B. t. u. by Calorimeter	
Per Cent. Sulphur	

M. E. Co. No. ..... Their No. .....

FIG. 5. ALL COAL IS PURCHASED UNDER CONTRACT, PAYMENT BEING MADE ON THE BASIS OF 8 PER CENT ASH BY ANALYSIS

METROPOLITAN EDISON COMPANY
WEST READING PLANT
READING, PA.

DAILY COAL REPORT

Date ..... 192.... From ..... M. to ..... M.

Boiler No.	Last Reading	Present Reading	Difference	Total Pounds
1				
2				
3				
4				
5				
6				
24				

Pounds Coal Consumed	
K. W. Hrs. Generated	
Pounds Coal per K. W. Hr.	
Station Load Factor	
Tons of Ash Removed	
Relative Plant Economy	%

Checked by ..... Calculations by .....

FIG. 6. DAILY COAL REPORTS ARE MADE UP FOR EACH UNIT IN OPERATION

is taken from deep wells and sterilized by means of ultra-violet rays. Further tests are run on all general supplies such as insulators, fire brick, cement, etc. An attendant of the laboratory is responsible for the maintenance, repair and operation of all instruments about the plant, each instrument is inspected three times each day and calibrations are made when necessary. All recorder charts are changed at midnight.

Feed Water and Blow Downs

With the present condenser equipment, all water fed to the boilers must be treated raw water. Feed water may be taken from either of two sources, Wyomissing Creek or the Schuylkill River; the normal supply comes from the former. However, should an attendant open the river water valve, this fact is indicated in the laboratory by a signal lamp and recorder; in this way, the change is shown and the treatment may be altered to meet the new conditions.

Principal incrustants found in the feed water are calcium and magnesium sulphate, which are broken down by the addition of sodium carbonate. Tests have determined that the creek water contains three parts per 100,000 of chlorides, whereas the boiler water concentration averages about 29 parts of chloride per 100,000.

Weighing and mixing of the soda ash is under the care of a laboratory attendant. Two mixing tanks are located so that the mixture will flow by gravity to open feed water heaters where it is intimately mixed with the feed water. A sight feed is located in the turbine room so the turbine operators can see at a glance if the soda ash solution is being fed. In the laboratory are

Form No. 296-5-20-23-500 METROPOLITAN EDISON COMPANY
TESTING BUREAU LABORATORY
READING, PENNA.

PROXIMATE ANALYSIS OF ASH AND COAL

For _____ 192_ Date Analyzed _____ 192

SHIFT NUMBER	BOILERS	FIREMAN	Weight of CRUCIBLE PLUS SAMPLE	WEIGHT LESS FIXED CARBON	% FIXED CARBON	% ASH
1	1 to 8 inc.					
1	9 to 16 inc.					
1	17 and 18					
1						
1						
1						
2	1 to 8 inc.					
2	9 to 16 inc.					
2	17 and 18					
2						
2						
2						
3	1 to 8 inc.					
3	9 to 16 inc.					
3	17 and 18					
3						
3						
3						
Average	By Calculation					
Average	By Analysis					

ANALYSIS OF COAL

	SHIFT No. 1		SHIFT No. 2		SHIFT No. 3	
Weight of Crucible Plus Sample						
Weight Micro Moisture						
Weight Micro Fixed Carbon and Vol. Matter						
Weight of Crucible Plus Sample						
Weight Micro Volatile Matter						
Per Cent Moisture and Volatile Matter						
Per Cent. Moisture						
Per Cent. Volatile Matter						
Per Cent. Fixed Carbon						
Per Cent. Ash						
Btu by Analysis						
Btu by Calorimeter						
Per Cent. Sulphur						

Approved _____ Analyzed by _____ M.E.Co. No. _____

FIG. 7. COAL AND ASH ANALYSIS ARE INSTRUMENTAL IN FIGURING UP THE BONUS WHICH IS BASED ON THE PER CENT COMBUSTIBLE IN ASH

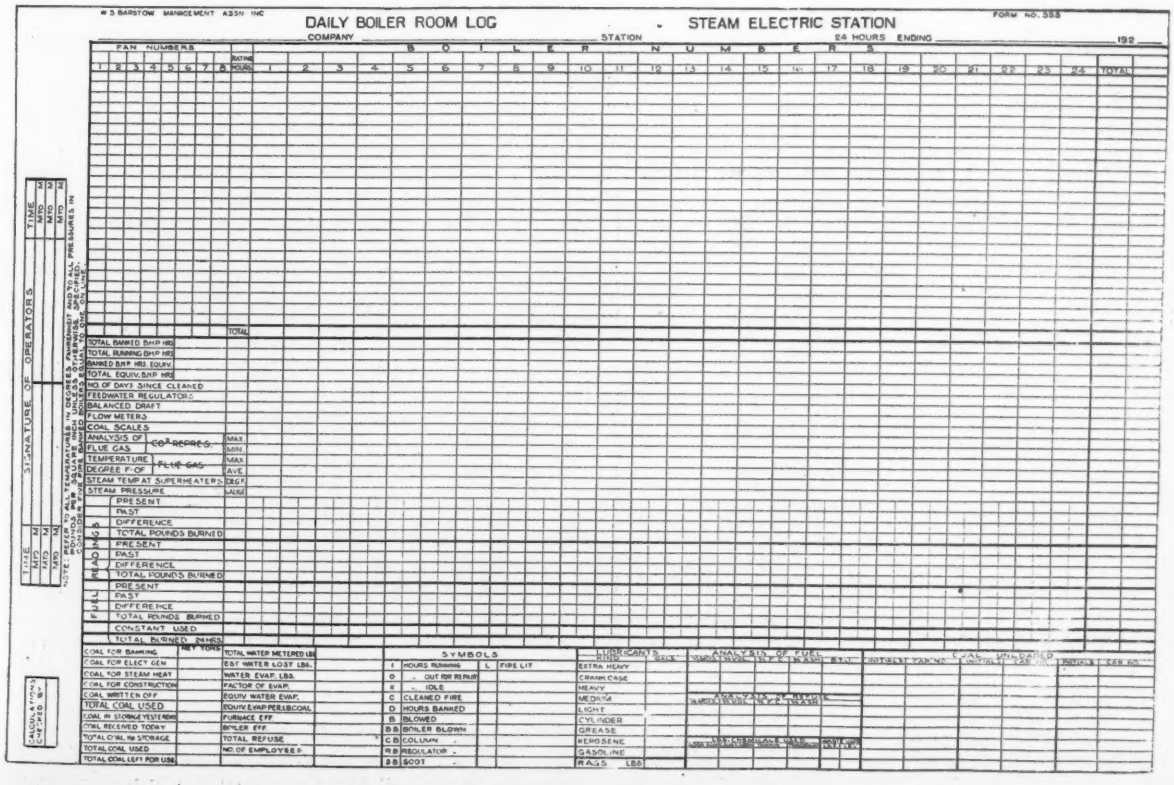


FIG. 8. CHART USED FOR DAILY BOILER ROOM LOG

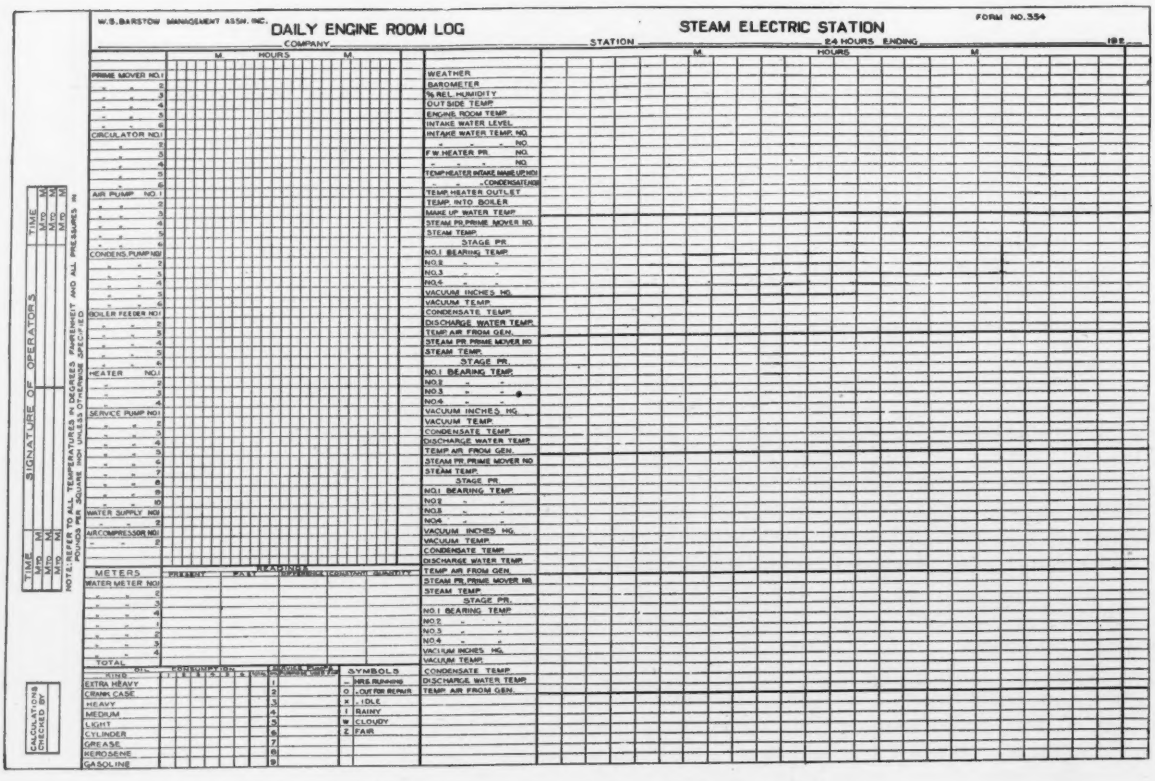


FIG. 9. CHART USED FOR DAILY ENGINE ROOM LOG

located signal lamps which indicate when a predetermined low level is reached in the mixing tanks.

Each boiler is provided with a tap in the rear header, this tap being located about 12 in. above the bottom of the header. Every morning a 250-cc. sample of water from each boiler is taken to the laboratory and allowed to cool and settle. Two 25-cc. samples are taken from each boiler sample, one being used for the test of chlorides while the other is used for making up an average sample. From the first sample is determined

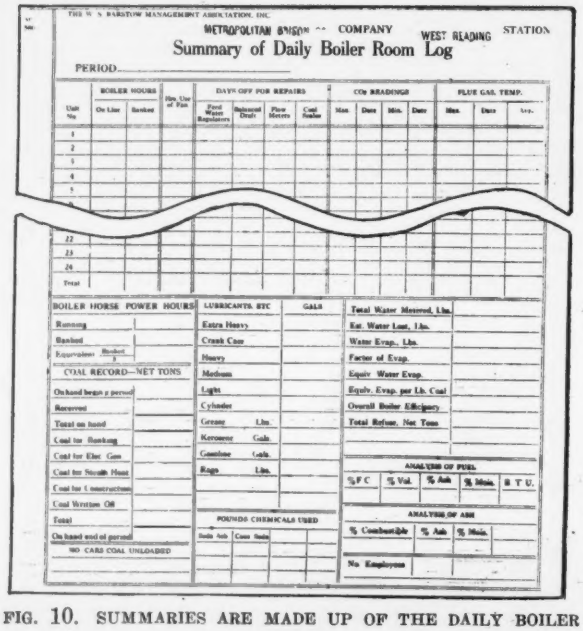


FIG. 10. SUMMARIES ARE MADE UP OF THE DAILY BOILER ROOM LOGS

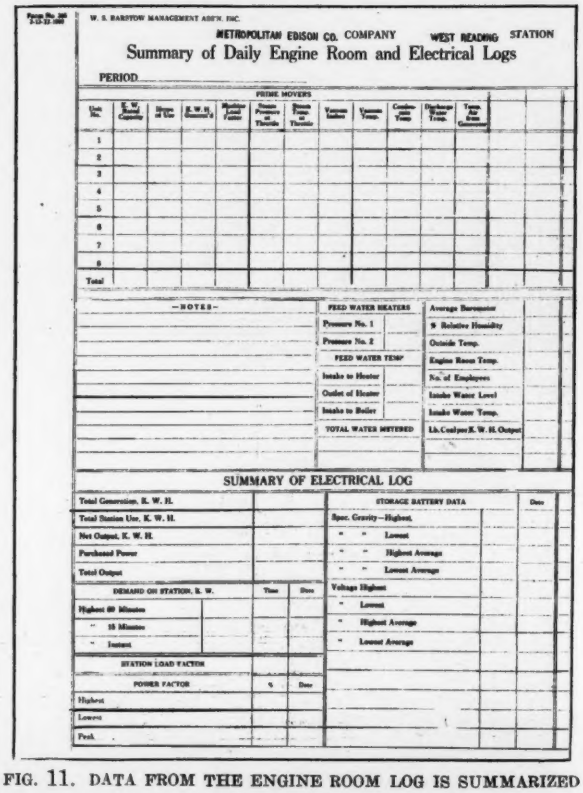


FIG. 11. DATA FROM THE ENGINE ROOM LOG IS SUMMARIZED ON THIS FORM

the amount of foreign matter in the boiler, and on observation it will be found that by a comparison of these results the work of the boiler can be calculated, knowing, of course, the amount of chlorides in the feed water before it was treated.

From the results of many practical tests, charts have been prepared which indicate the amount of blow down necessary under a stated condition of concentration. For example, if a test on one of the boilers showed that there were present 40 parts of chlorides per 100,000, then the procedure would be to blow down that boiler 10 in. on the water glass. Instructions are issued to the boiler room foreman as to when and how much each boiler must be blown down. This may mean that some of the boilers will not be blown for 24 hr., while others may be blown down from one to three times during this period, as conditions require.

Boilers are not blown down until they have been banked from one to two hours; it has been found that this length of time is required after steaming before the dirt and sludge have settled so that they can be effectively removed. A blowdown during the steaming period will rid the boiler of only that sludge which happened to be in the lower tubes at the time.

Samples to Show Settling of Sludge

Results obtained from the methods of sludge settlement determination are considered of great importance. By observation, the sample which has the lightest and that which has the heaviest precipitate are picked out, and the two are then poured together and well shaken and the time required for the precipitate to settle is then noted. This should be within about one hour and should come down so that the water is perfectly clear. Once in a while trouble is experienced in that the precipitate does not settle out satisfactorily; the remedy resorted to is to cut down temporarily on the amount of soda ash used and to add a few pounds of starch or alum.

Use of the Average Sample

Hardness, alkalinity and causticity are determined from the average sample by the usual laboratory methods. The amount of soda ash to be added to the feed water can then be calculated although the theoretical amount required has been found to be excessive; therefore an arbitrary or normal hardness of 2.5 has been established and an effort is made to keep the hardness of the water in the boilers at that point.

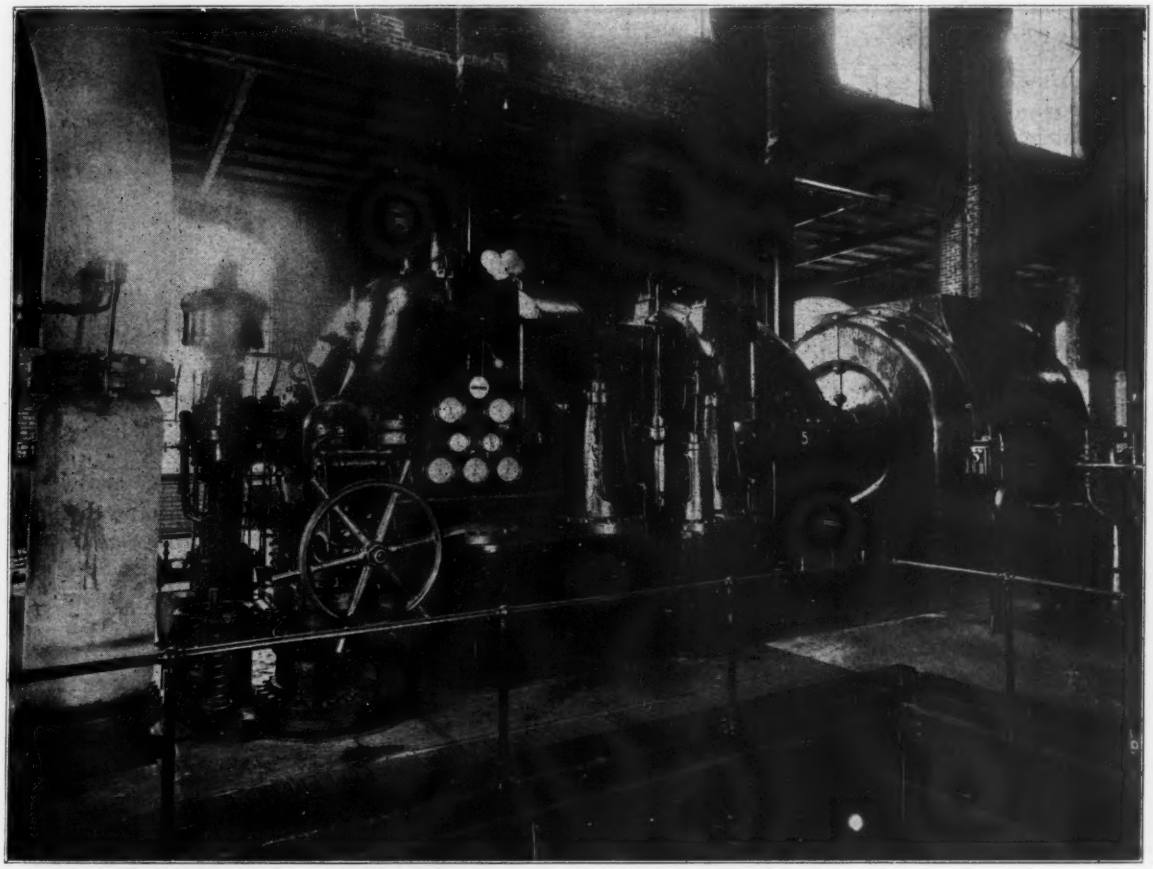
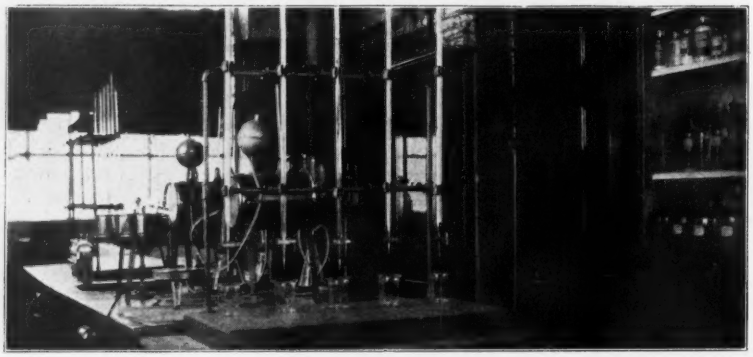


FIG. 12. PRESENT 25,000 KV.A. WESTINGHOUSE UNIT

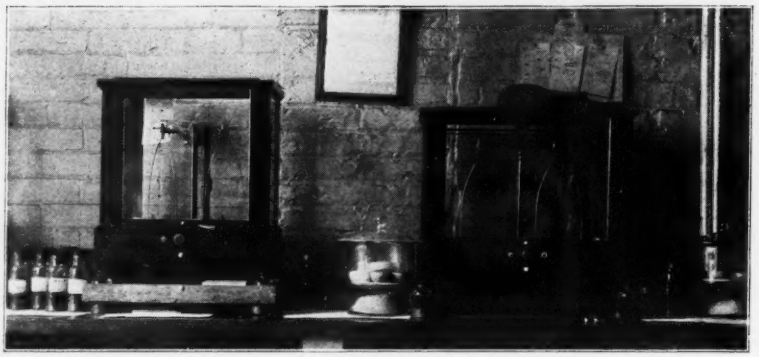
These are the principal tests to which the feed water is subjected in this plant. A constant watch is kept on all piping which carries the treated water, and the concentration of soda ash is not allowed to become excessively high. The feed water heaters are arranged so that they may be cleaned once a week or more often if necessary.

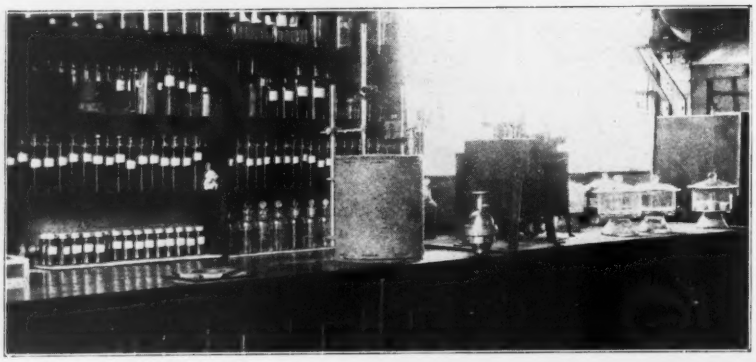
An interesting feature has been developed at this plant to provide boiler treatment in proportion to the



EQUIPMENT IS COMPLETE FOR THE ANALYSIS OF ALL OILS REQUIRED IN POWER PLANT PRACTICE. A CAREFUL WATCH IS KEPT ON THE BEARING OIL USED IN EACH MAIN UNIT. A TEST SAMPLE IS DRAWN FROM EACH UNIT ONCE A MONTH.

BALANCES ARE REQUIRED FOR THE ANALYSIS OF BOTH COAL AND ASH. THE BONUS SYSTEM IS BASED UPON THE GUARANTEED STOKER PRACTICE, THE ASH CONTENT OF THE COAL AND THE PER CENT OF COMBUSTIBLE IN THE ASH.





AN EMMERSON BOMB CALORIMETER IS USED TO DETERMINE THE B.T.U. OF THE COAL RECEIVED. THE COAL COMPANY IS PENALIZED OR PAID A PREMIUM BASED ON AN ASH CONTENT OF THE COAL OF 8 PER CENT.

GENERAL VIEW OF LABORATORY SHOWING WORK BENCHES, VENTILATED HOODS AND HEATING OVEN. THE DRINKING WATER, WHICH IS TAKEN FROM DEEP WELLS, IS TESTED THREE TIMES EACH WEEK.

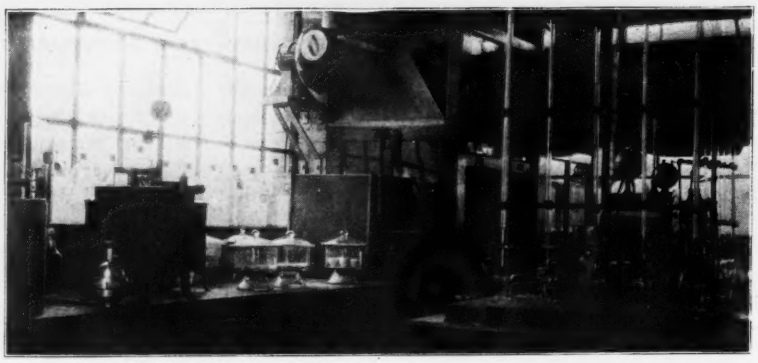


FIG. 13. VIEWS IN TESTING BUREAU LABORATORY. THE EQUIPMENT IS UNUSUALLY COMPLETE. THE WORK PERFORMED HERE IS NOT PURELY ANALYTICAL BUT IS CLOSELY TIED IN WITH PLANT OPERATION

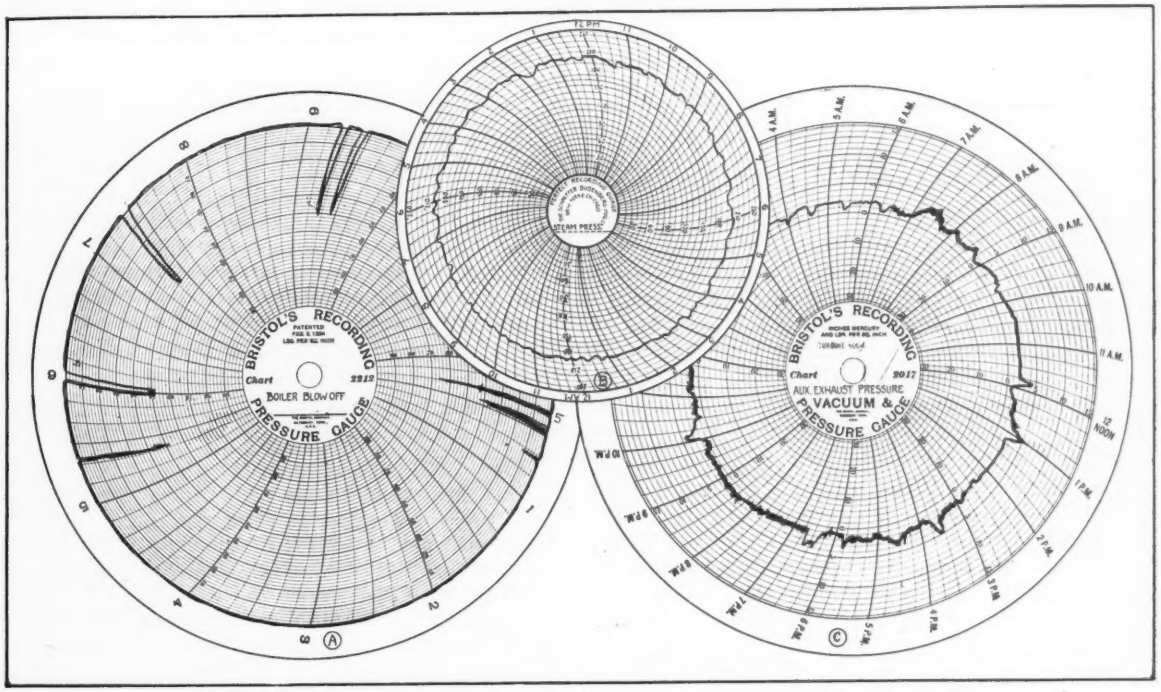


FIG. 14. RECORDING INSTRUMENTS ARE THE RULE AT THE WEST READING PLANT

(A) Records of blowoff are made to check the operators as to obedience to instructions. (B) Steam pressure recorders are located in the chief engineer's office and at the main switchboard. (C) Steam driven auxiliaries operate at from 1 to 2 lb. back pressure.

load. In the main switchhouse are located two machines similar to dictographs, except that the rotating cylinders are of metal and are studded with electrical contact points.

In place of the usual diaphragm recorder is a contact which is moved by the switchboard attendant back and forth along a scale graduated in thousands of kilowatts. Suppose the station load is 30,000 kw. The attendant sets the movable contact at that point on the scale, and as the cylinder revolves, a certain number

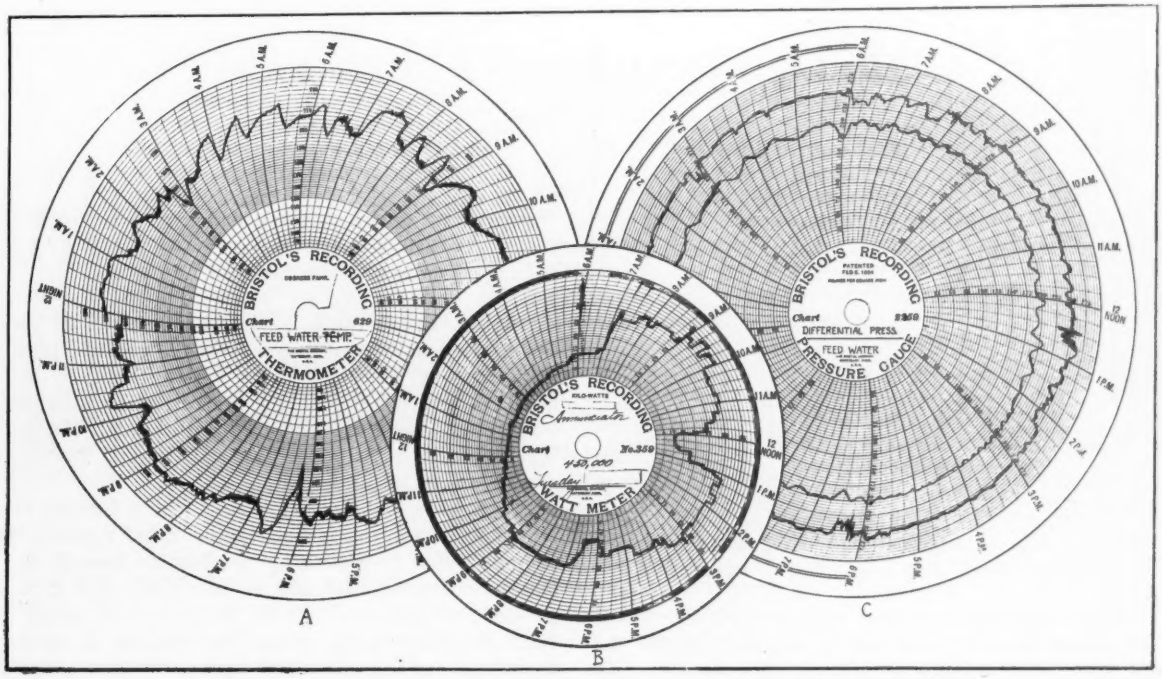
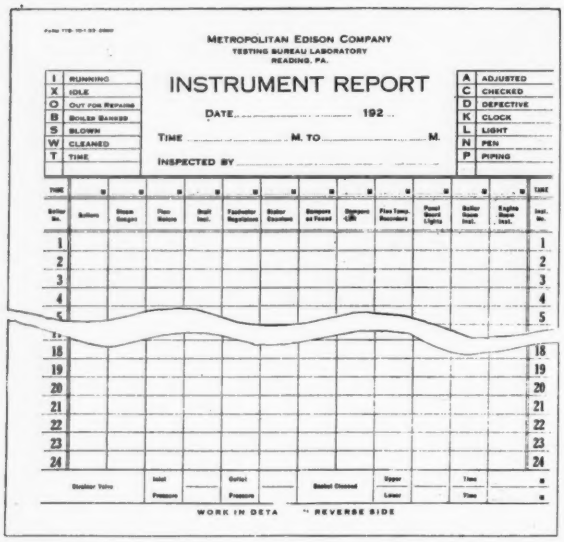


FIG. 15. ACCURACY OF ALL RECORDERS IS ASSURED BY THREE DAILY INSPECTIONS

(A) Feed water temperature averages well around the 212 deg. F. mark. (B) The load annunciator records at the main switchboard and indicates the load in the boiler room and the chief's office. (C) Steam pressure is maintained at about 200 lb. while the feed water pressure is kept at about 250 lb. pressure.

of contacts are made and broken each minute. These contacts are wired to a magnetic escapement which in turn is attached to the floating end of the outlet pipe in one of the mixing tanks. The number of contacts made each minute determines the amount that the outlet pipe is lowered and accordingly the amount of the soda ash solution that is fed to the heaters.

Should the load decrease the attendant would move the contact to correspond with the load. It would meet with a less number of contacts on the cylinder and a corresponding less amount of the solution would be fed to the heaters.


METROPOLITAN EDISON COMPANY
TESTING BUREAU LABORATORY
READING, PA.

INSTRUMENT REPORT

DATE ..... 192 ..

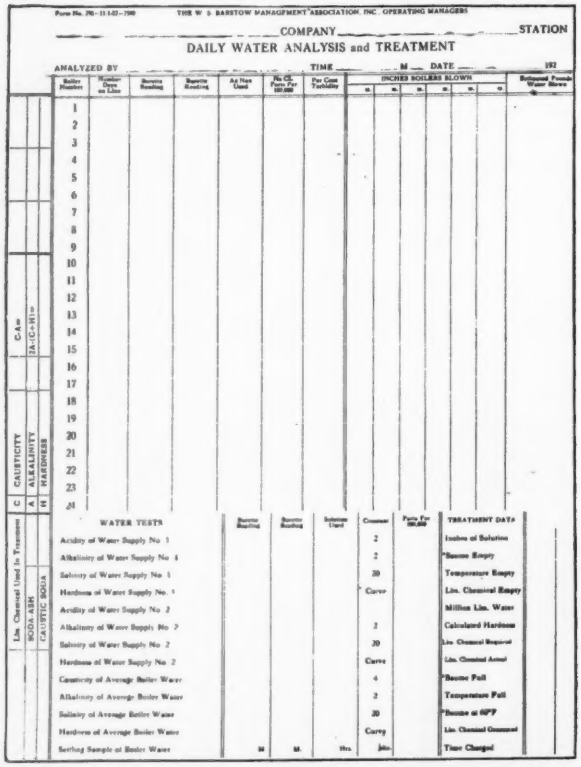
TIME ..... M. TO ..... M.

INSPECTED BY .....

I RUNNING
X IDLE
O OUT FOR REPAIRS
B BOILER BANKED
S BLOWN
W CLEANED
T TIME

A ADJUSTED
C CHECKED
D DEFECTIVE
K CLOCK
L LIGHT
N PEN
P PIPING

FIG. 16. ALL INSTRUMENTS ARE MAINTAINED BY THE TESTING BUREAU LABORATORY


THE W. S. BARSTOW MANAGEMENT ASSOCIATION, INC. OPERATING MANAGERS

COMPANY STATION

DAILY WATER ANALYSIS and TREATMENT

ANALYZED BY TIME M. DATE 192

WATER TESTS

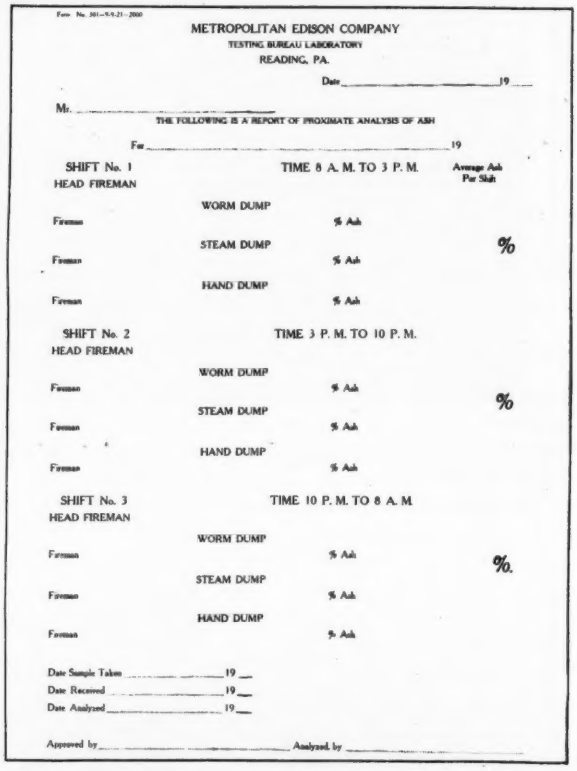
TREATMENT DATA

FIG. 17. CAREFUL TESTS ARE MADE AND COMPLETE RECORDS KEPT OF FEED WATER ANALYSIS AND TREATMENT

Furnace Maintenance

Arches and furnace walls are not allowed to thin down more than about 2 in.; a mixture of ganister and high temperature cement is then applied by means of a cement gun so that you might say that the furnaces are in first class condition at all times.

Stoker speeds and the dampers are operated manually, whereas the forced blast fans are controlled by Mason regulators. Each boiler is equipped with a Copes feed water regulator, a General Electric flow meter and a 3 in 1 Precision draft gage.


METROPOLITAN EDISON COMPANY
TESTING BUREAU LABORATORY
READING, PA.

Date ..... 19 ....

Mr. .....

THE FOLLOWING IS A REPORT OF PROXIMATE ANALYSIS OF ASH

For 19

SHIFT No. 1 TIME 8 A. M. TO 3 P. M. Average Ash Per Shift
HEAD FIREMAN
WORM DUMP
Fireman % Ash
STEAM DUMP %
Fireman % Ash
HAND DUMP
Fireman % Ash

SHIFT No. 2 TIME 3 P. M. TO 10 P. M.
HEAD FIREMAN
WORM DUMP
Fireman % Ash
STEAM DUMP %
Fireman % Ash
HAND DUMP
Fireman % Ash

SHIFT No. 3 TIME 10 P. M. TO 8 A. M.
HEAD FIREMAN
WORM DUMP
Fireman % Ash
STEAM DUMP %.
Fireman % Ash
HAND DUMP
Fireman % Ash

Date Sample Taken ..... 19 ..
Date Received ..... 19 ..
Date Analyzed ..... 19 ..

Approved by ..... Analyzed by .....

FIG. 18. THIS FORM IS USED TO REPORT THE QUALITY OF ASH MADE BY EACH FIREMAN AND SHIFT

Stoker fans all discharge into a common duct which can be sectionalized so as to obtain the greatest possible flexibility of fan operation. Two Venturi meter mechanisms are provided for recording the boiler feed water flow; these are operated not through the usual Venturi tube, but through General Electric flow meter nozzles placed in the feed line.

Each main turbine is furnished with a General Electric flow meter in addition to the usual pressure and vacuum gages furnished by the turbine manufacturer. The switchboard attendant is furnished with a steam pressure recorder and a watt meter recorder annunciator. By means of the annunciator a signal in the main firing aisle and in the chief engineer's office show the load in thousands of kilowatts that is on the station at any one time. A steam pressure recorder is also located in the chief engineer's office.

The 25,000 kv.a. generator is cooled by a motor driven fan and rather an ingenious device has been installed on the air duct to notify the operators in case this fan fails. It is, essentially, a light weight poppet valve held open by the air pressure. Should the air supply fail, this valve will drop and close an electrical circuit that rings a bell and lights a warning lamp on the switch-board gallery. This electrical circuit is interlocked with the main oil switch, so that, should the air be cut off, the bell will continue to ring until the oil switch is opened.

System of Bonus Payment

Ash cars are provided into which the ash is dumped directly from the setting hoppers; a skip hoist then elevates the ash to an overhead hopper. From this hopper the ash is discharged into a 3000 cu. ft. car, in which it is hauled away to the dump. As each ash hopper is dumped, a sample is taken from which one average sample is made up for each shift and for each group of boilers that are under the control of a fireman; there are three 8-hr. shifts, therefore, nine ash samples are analyzed each 24 hr. The percentage of combustible found in each ash sample is compared to the standard stoker performance guarantee and the percentage of ash found by laboratory analysis in the coal from which the sample of ash in mind was made.

Practice has established certain limits of operation, so that if the fireman is negligent he earns only his guaranteed wage; on the other hand, should he hold down the combustible content in the ash he will be paid a bonus. The combustible in ash basis of paying bonus has been successfully applied after the CO_2 basis had been tried and had failed. Sunday industrial loads are light, therefore the bonus is figured on a six day week. In order to keep the bonus payment equitable, it has been found necessary to rotate not only the three shifts, but also to change the men from one shift gang to another.

Standard Practice Being Developed

At the present time the management is soliciting cooperation from its employes in the preparation of a loose leaf book of standards of operation, maintenance and methods. This, it is expected, will work towards uniform practice in all the properties controlled by the Metropolitan Edison Company.

Organization at the West Reading Plant consists of the chief engineer, to whom report directly the record clerk, the engine room foreman, the boiler room foreman, chief of the testing bureau laboratory, the switchboard foreman, the chief electrician, and the foreman of coal docks.

Engineers, assistant-engineers, oilers, wipers and water screen men report directly to the engine room foreman. Switchboard operators and system operators report to the switchboard foreman. Crane operators and electricians report directly to the chief electrician. Head firemen, brick layers, pipe fitters, machinists, repairmen and boiler cleaning men report to the boiler room foreman. The head fireman is responsible for the stoker operators, coal passers, and firemen.

Wiring diagrams for all electrical equipment about the plant have been made on letter size paper. A complete file of these diagrams is kept by the chief electrician; it has been found that this greatly facilitates maintenance and repair work.

This plant is under the supervision of the W. S. Barstow Management Association, Inc., of which E. M. Gilbert is vice-president and chief engineer. It was through Mr. Gilbert's courtesy and co-operation that this article was prepared.

Economic Generation of Power

Modern Methods of Obtaining the Greatest Thermal Efficiency in the Operation of Power Plants. By L. L. Bowen*

IN THE operation of a power plant, heat balance is a subject which is receiving a great amount of attention these days. The purpose of a heat balance in a power station, is to transfer into useful energy as much as possible of the total heat generated, with the least possible waste, and with a minimum expenditure of coal. There are in use today various methods of obtaining these results. Some of these methods, while apparently very efficient, have inherent losses which can be determined only by very careful study. Methods employed for conserving the heat generated in power stations include:

(1) The use of economizers and air pre-heaters for decreasing the waste of heat in the flue gases.

(2) Utilizing the exhaust steam from steam driven auxiliaries for heating feed water or in evaporators for obtaining distilled make-up water.

(3) Bleeding the main unit and utilizing the latent heat of the steam for heating feed water, thereby decreasing the amount of heat that would be carried away in the circulating water of the condenser.

(4) Recovering the heat losses in the bearing and transformer oil, by circulating the condensate through the oil coolers.

(5) Recovering the turbo-generator losses by using a closed air cycle on the generator, and cooling the air by means of the condensate.

There are various combinations of the above-mentioned methods of decreasing the waste heat in central stations today, some using only one or two of the preceding items and others employing nearly all of them together. Stations employing nearly all of these methods of decreasing waste heat are only the large central stations with a high load factor. Investment will not warrant the use of complicated systems of heat balance in the smaller power station with a load factor.

There is a general belief among engineers at present that we have reached a point beyond which little improvement can be expected in increased boiler efficiency and turbo-generator efficiencies, with present pressures, temperatures, and equipment. Hence our only way of improving the thermal efficiency of steam power stations is through the heat balance system.

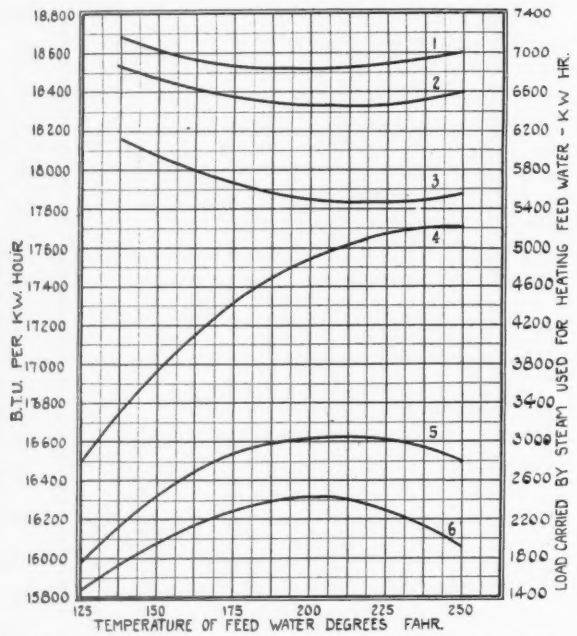
* Engineer, Westinghouse Electric and Manufacturing Co.

Method of Auxiliary Drive

Intimately connected with the question of heat balance, is the question of auxiliary drive. In laying out auxiliary drives, the following must be given consideration:

(1) Reliability of operation.
(2) First cost and operating cost.
(3) The thermal efficiency of the plant.
(4) The flexibility of the system in view of possible future developments and changes in power plant equipment.
(5) Load factor.
(6) Correct heat balance at varying loads.

Reliability of operation is of paramount importance in considering the type of auxiliary drive. Station efficiency must sometimes be sacrificed for reliability. Reliability of auxiliary equipment, such as boiler feed pumps and exciters, and high plant efficiency, is also of prime importance.



CURVES SHOWING B.T.U. NECESSARY FOR DIFFERENT WATER TEMPERATURES WITH DIFFERENT SYSTEMS

With a variable load factor and variable circulating water temperature, it is important to have a flexible system of obtaining the heat for a proper feed water temperature.

Cost is a determining factor in the selection of auxiliary drive. The initial cost of installation and cost of operation must also be given careful consideration, for we are ultimately interested in keeping down the cost of power output. The thermal efficiency of the plant should also be worked out for the different methods of obtaining a heat balance and with different feed water temperatures. The system giving the lowest B.t.u. per kw.-hr. is the one to choose from a thermal efficiency standpoint alone. The reciprocating steam engine drive made its appearance first and it was followed by the turbine. By the use of reduction gears, the steam consumption of turbine driven auxiliaries has been practically cut in half, as compared with direct-connected units.

Bleeding Steam

One of the greatest advantages of steam driven auxiliaries is reliability of service, as in case of line trouble, the more important of the auxiliaries, such as boiler feed pumps and condenser auxiliaries, are not interrupted. It was the practice in stations with steam driven auxiliaries so to proportion the non-condensing auxiliaries that the feed water was heated to about 210 deg. F. at average load on the main unit; but at lighter loads it meant a waste of steam to the atmosphere, and a lower feed water temperature at higher loads. To overcome this difficulty a series of valves, for obtaining a correct heat balance, were brought out. At times of lighter loads when there would be an excess of exhaust steam, these valves admitted the excess exhaust steam into the low pressure stages of the main unit; at higher loads, when there was a deficiency of exhaust steam, steam was bled from the main unit for heating the feed water.

Today, it is the practice in central stations installing steam driven auxiliaries to obtain a heat balance by so proportioning their auxiliary drive between steam and motor (with a duplex drive on the circulating pump for flexibility) that the correct amount of exhaust steam is always available for feed water heating. By varying the load between the motor and the turbine of the duplex drive, the required amount of exhaust steam may be obtained for various plant loads. In order to determine the horsepower of steam driven auxiliaries and have the correct amount of exhaust steam to heat the feed water to the proper temperature for best efficiency, the following formula may be used:

$$hp. = \frac{M\,(Tf - Te)}{W\ \ He}$$

hp. = Total horsepower of steam driven auxiliaries
M = Weight of feed water to be heated per hour.
Tf = Final temperature of feed water.
Te = Initial temperature of feed water.
W = Water rate of steam driven auxiliaries in pounds per brake horsepower.
He = Available heat in exhaust steam above temperature Tf.

Assuming a boiler efficiency of 75 per cent we are producing a kilowatt-hour with 4550 B.t.u. on the steam driven auxiliaries, as against about 18,000 B.t.u. on the main unit. In order to increase the thermal efficiency of our plant, we want to produce as much of this cheap power as possible. With a given feed water absorption capacity, it will be necessary to select the steam driven auxiliaries with as low a water rate as possible in order to generate as much of the cheap power as possible, since the total quantity of exhaust steam required is fixed by the amount of water to be heated.

By reference to curve 1, in the accompanying chart, which shows the B.t.u. per kw.-hr. against feed water temperature using steam driven auxiliaries, it will be noted that this curve lies higher than curves 2 and 3, which represent systems using a turbine and bleeding the main unit respectively, with motor driven auxiliaries, as explained later. The curves on the chart are based upon a net station output of 50,000 kw. with a total generated load of 53,000 kw. This is based on auxiliary power requirements being assumed as 6 per cent of the station output. The water rate of the station steam

driven auxiliaries increases with the back pressure on the unit. In properly designed heaters, the temperature nearly corresponds with that due to the back pressure. We have taken a boiler efficiency of 75 per cent and water rate on main unit of 11 lb. per kw.-hr.; steam pressure 300 lb., superheat 200 deg. at throttle.

Use of House Turbine

The house turbine with motor driven auxiliaries has rapidly replaced the steam driven auxiliaries in modern stations due to a lower water rate, and the possibility of operating the turbine under a vacuum at partial loads. It is also a material advantage in reliability to have a separate generating unit to supply the more important motor driven auxiliaries. With this system the auxiliaries are usually motor driven, with the exception possibly of the boiler feed pumps. These auxiliaries exhaust their steam into an evaporator for obtaining distilled make up water.

With the auxiliaries electrically driven and supplied with power from the turbine, in order to maintain some predetermined feed water temperature, power must be supplied from the main unit to the auxiliaries at light station loads, while at heavy station loads the turbine might have to generate more power than the auxiliaries require, the surplus being transmitted to the main bus. This requires the turbine to run in parallel with the main units. The disadvantage of this scheme is that a system disturbance which drops the voltage and frequency of the main unit will affect the turbine operation. Even if relays are used to disconnect the turbine from the main bus under abnormal conditions, they may not operate quickly enough to prevent trouble. To overcome this difficulty, the transfer of power from the main bus to the auxiliary bus can be made through a motor-generator set.

Sufficient resistance is connected in motors rotor circuit so that when it is loaded it will run 5 per cent slower than at no load. With 60-cycle current on the main system, the generator on house turbine and motor-generator set is designed for 57 cycles. The feed water temperature is registered on an instrument in the operating room so that the operator may make proper adjustments of load on house turbine to maintain the temperature of feed water constant. The governor setting on the house turbine is changed to take more or less load, through a small motor and worm gear, controlled from the operating room.

By selecting a house turbine large enough to take care of all loads and to give a proper feed water temperature for best efficiency, we have a very flexible system of feed water heating besides furnishing a standby source of power for station auxiliaries in the event of a system failure.

One of the disadvantages of the house turbine is the large item of initial expense and the no-load losses of this unit. When not carrying load, a certain amount of steam is required by this unit. This steam represents so much wasted energy not obtained from press drop, as it may be looked upon as being throttled through an ordinary throttle valve. The no-load losses of a house turbine will average about 10 per cent but when compared to the station output of 50,000 kw. these losses become almost negligible.

In the accompanying chart, curve 2 shows the computed cost of power for variable feed water temperature and variable house turbine steam consumption, with fixed initial steam conditions. Increasing the temperature of the feed water decreases the cost of power from the main unit. As the temperature of the feed water increases, the amount of exhaust steam required to heat the feed water increases, thus permitting the generation of more cheap power by the house turbine. With an increase in exhaust or back pressure of the house turbine corresponding to an increase of feed water temperature, the water rate of the house turbine increases. This increase in water rate reduces the proportion of cheap power generated and eventually we reach a feed water temperature at which an increase of back pressure on the house turbine will decrease the station economy. For higher feed water temperatures, curve 1 will bend upwards, thus increasing the B.t.u. per kw.-hr.

Use of Extraction Heater

In many cases the house turbine will be replaced by the extraction heater in the central stations under contemplation. If a house turbine will be used at all the tendency will probably be to use a smaller house turbine for reliability and obtain the major part of the steam for feed water heating by bleeding the main unit.

This system of bleeding the main unit offers the maximum thermal efficiency. This fact is brought out by reference to curves 1, 2 and 3, which show the heat consumption per kw.-hr., when heating feed water to different feed water temperatures and obtaining steam for feed water heating from steam-driven auxiliaries, a house turbine, and bleeding the main unit respectively. Curves 4, 5 and 6 show the loads carried by bled steam, the house turbine and steam-driven auxiliaries respectively against feed water temperature. It should be observed that the maximum station efficiency is obtained at that feed water temperature which corresponds to the greatest load on the unit supplying the exhaust steam for feed water heating. As can be readily seen from those curves, if the feed water is heated to a temperature above or below a certain range of temperature within which the curves are fairly flat, the station thermal efficiency is decreased. The efficiency of conversion of heat energy into mechanical energy is enormously greater in a large main unit turbine than in a small auxiliary turbine, although the exhaust steam taken from the main unit at atmospheric pressure has done only about 50 per cent more work than a pound of steam taken from the auxiliary turbine at atmospheric pressure.

Welded Pressure Vessels

For several years efforts have been made to draw un a code for the welding of unfired pressure vessels. Opinions of the best welding experts were not in agreement on many essential points. Fundamental, scientific knowledge, based on test data was not available. The American Bureau of Welding (Research Department of the American Welding Society), has completed a series of tests on some fifty tanks. The program involved an expenditure of over $15,000. The test data, analysis of same conclusions and recommendations to the Boiler Code Committee of the A. S. M. E. have been compiled in a report, copies of which may be obtained from the American Welding Society, 33 West 39th St., New York.

The Don Pedro Hydroelectric Plant

NOVEL FEATURE OF PLANT IS THAT IT IS DESIGNED TO OPERATE ON HEADS VARYING FROM 120 TO 240 FT. BY CHARLES W. GEIGER.

ONE OF THE most recent hydroelectric developments to be placed in operation on the Pacific Coast is the plant built in connection with the Don Pedro Dam in Tuolumne County on the Tuolumne River, about 6 mi. above the town of La Grande, Stanislaus County, Calif. This plant is part of a combination power and irrigation project, carried out primarily to increase water storage for irrigating 150,000 acres of land in the San Joaquin Valley. The dam is of the concrete arch type, 283 ft. in height, and creates a water storage of 289,000 acre-feet.

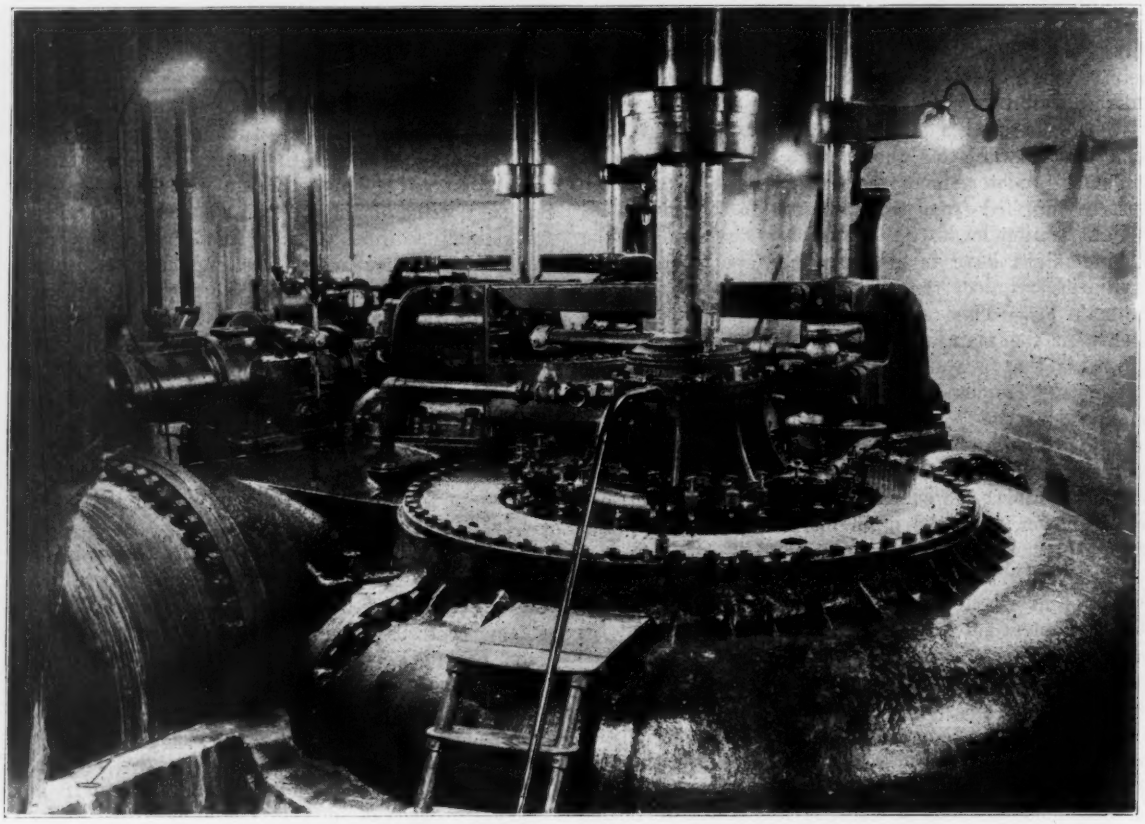


FIG. 1. TWO OF THE 6700-HP. HYDRAULIC TURBINES

PLANT OPERATES ON VARIABLE HEAD

This power plant is unique in that it was designed to operate at maximum efficiency at 160 ft. head, but must also be able to operate at heads as low as 120 ft. and as high as 240 ft., the maximum head. The variation in head from 120 to 240 ft. is unusual. At 240 ft., the efficiency of the turbines is 83 per cent.

Water is supplied to the turbines through circular conduits 6 ft. in diameter and 210 ft. long, consisting of concrete lined openings in the dam connecting with concrete lined tunnels beneath the power house foundation, to the turbines which are located in an open excavation below the floor of the generator room. Each penstock is controlled at its upper end by a valve which is operated by an oil pressure cylinder electrically controlled from the power plant switchboard. Each generator is connected to a bank of three single-phase transformers and each transformer bank is connected through a non-automatic electrically operated oil circuit breaker to the middle leg of a double throw disconnecting switch by which it may be connected to either of two sets of 66,000 v. bus bars.

It is possible that additional units may later be installed to make an ultimate development of five 5000-kv.a. units and provision is made for extending the high tension bus bar system to receive additional units.

Power is supplied to the valley over a 33-mi. twin circuit, steel pole transmission line at 66,000 v. The two outgoing circuits are tied to the bus bars of the station by double throw disconnecting switches and are controlled by automatic electrically operated oil circuit breakers. Each circuit is provided with lightning arresters of the oxide film type.

Power will be supplied to general commercial load with a large proportion of induction motors driving centrifugal pumps. The plant is under contract to supply from 500 to 2500 hp. at 66,000 v. to a line of the Pacific Gas & Electric Co. to which service one of the outgoing circuits will be given for the present.

Penstocks supplying the turbines open into the reservoir 80 ft. above its bottom, 20 ft. below the lowest

water level, and 175 ft. below the surface of the full reservoir. The maximum head upon the plant will be 240 ft., the minimum head will be 120 ft. and the maximum draft tube head will be 20 ft. from the turbine floor. The primary purpose of the reservoir is irrigation storage and the general condition is that of a full reservoir with 240 ft. head from February to June, inclusive, with a large amount of water going to waste: a gradually diminishing head and flow to the end of September when the head is reduced to about 150 ft. and remains at this point with flow sufficient to operate but one unit for the next 3 mo.; and then a gradually increasing head and flow until the completion of the cycle at the beginning of February. Under exceptional conditions the head may be reduced to 100 ft. by the end of September and the flow to 300 sec. ft.

Water from the tail race, supplemented by that from independent irrigation outlets through the dam, is to be used to supply two large irrigation canals diverting the entire flow from the river a few miles below and requiring a uniform supply. To assist the irrigation outlets in maintaining the uniform supply to the canals and at the same time to give better operating conditions to the power plant, there is a synchronous bypass for each unit by which a flow as nearly uniform as practicable, and not less than 50 per cent of the full load flow shall be maintained through the penstocks independently of the load upon the power plant. Outside of the irrigation season it may be more important to save water than to improve the turbine regulation so that the synchronous bypass must be arranged for disconnection when desirable.

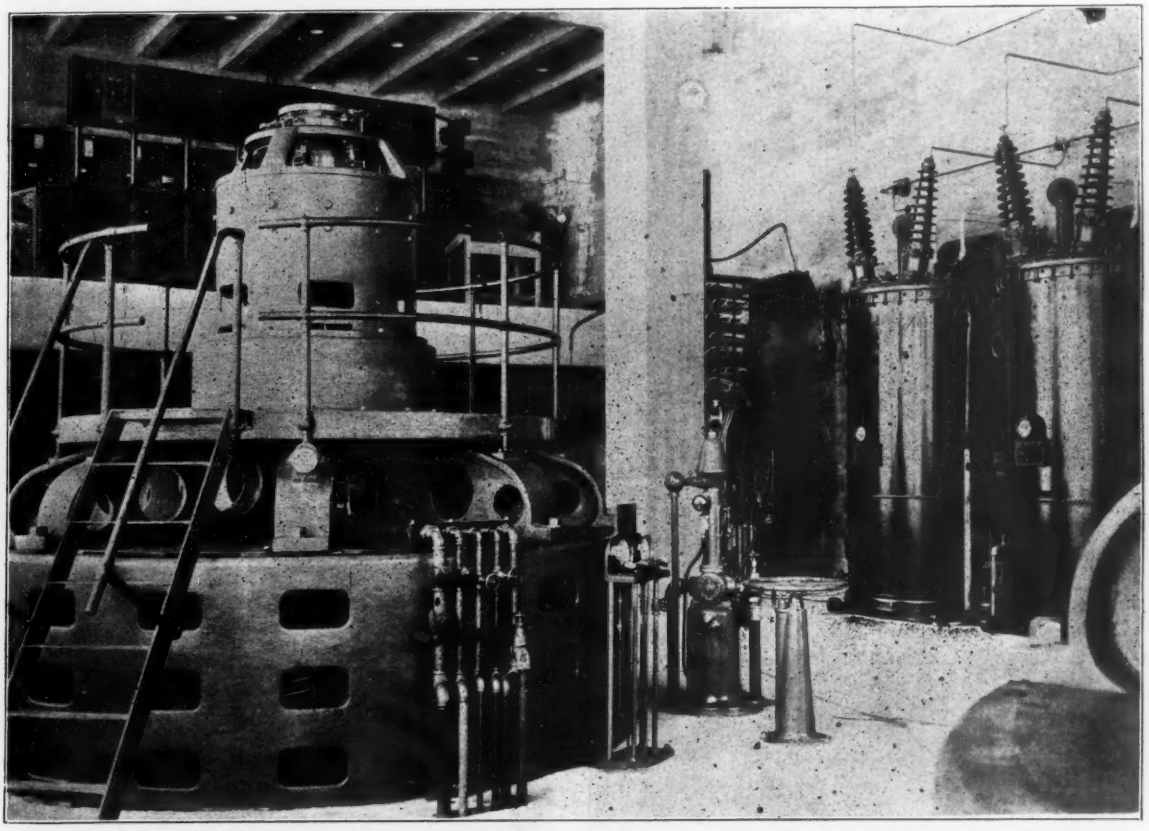


FIG. 2. GENERATOR ROOM, SHOWING TURBINE CONTROL IN THE FOREGROUND AT THE RIGHT OF GENERATOR

Generating Units

There are three generating units, each consisting of one 5000-kv.a., 3-phase, 60-cycle, a.c. General Electric generator of the vertical type, direct connected to an S. Morgan Smith, Francis type turbine of 6700 hp. capacity for 160 ft. head, but to operate with a variable head between 240 and 100 ft. Each generator is provided with a direct connected exciter.

For each generating unit there are three 1667-kv.a. single-phase, 60-cycle oil insulated water-cooled transformers for indoor use. These transformers are built for operation on 6600-v. delta secondary and 66,000-v. star connected primary and are insulated for operation with the neutral ungrounded.

Current for local service is provided by a bank of three 50-kv.a., 6600 to 440-v., single-phase, 60-cycle, oil-insulated, self-cooled, indoor type transformers.

Between each of the three banks of transformers and the bus bars there is provided a 400-amp. 73,000-v. indoor type, oil circuit breaker. The circuit breakers are electrically operated by 125-v. d.c. current controlled by pilot switches on the switchboard, and also are so arranged that they can be tripped by means of differential relays for the protection of each generator and each bank of transformers. They are non-automatic except as they are opened by the relays in case of internal trouble in the generators or transformers.

The plant will probably be enlarged by addition of two 5000-kv.a. units in the near future and may ultimately have a capacity of 50,000 kv.a. The circuit breakers have ample capacity to carry 400 amp. at 66,000 v. continuously and an interrupting capacity of not less than 2400 amp.

Each of the outgoing line circuit breakers have a continuous capacity of 400 amp. at 66,000 v. with an interrupting capacity of not less than 2400 amp.

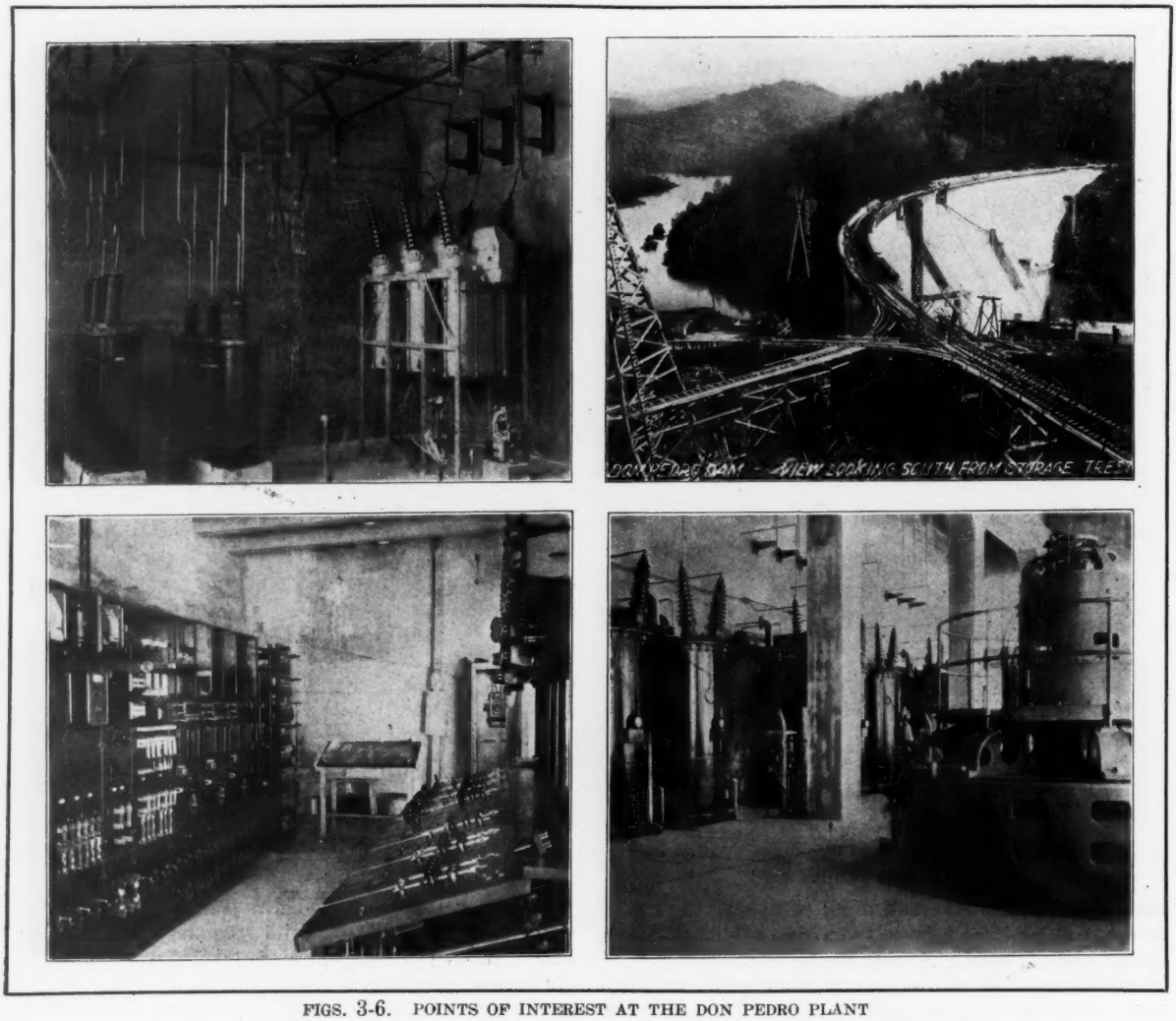
Details of Turbines

For the purpose of raising the generator above flood water level there is a 20-ft. shaft extension between the turbine and the generator. This extension was designed to operate satisfactorily without a guide bearing between the lower guide bearing of the generator and the turbine guide bearing. The weight of the runner and its shaft, together with its vertical reaction and the weight of the rotating parts of the generator and exciter are carried by a General Electric single vertical spring thrust bearing. The bearing consists of a runner of a special grade of cast-iron resting on a thin steel disc with a babbited surface. This babbited ring, in turn, rests on short helical springs and is held against rotation by dowel pins.

A tube in the center forms a retaining wall around the shaft for the oil. The helical springs are wound of ½-in. round wire and have an outside diameter of 2 in. and a free length of 1½ in. Under load the springs close about 3/32 in. and the total pressure is distributed upon all of them.

A cast-iron runner is located on the underside of the thrust collar which is fastened to the top end of the shaft by means of a retaining ring. The bearing surface of this runner is finished with extreme accuracy and is given a high polish. The babbit surface upon which this runner revolves has radial oil grooves cut in it, and it is cut entirely through in one of these grooves to prevent any tendency to dish or warp under changes in temperature.

The turbine shaft, made of forged carbon steel, is 12 in. in diameter, approximately 7 ft. 9 in. in length. The turbine gates are of the wicket type and made of steel. The gate stems turn in bronze bearings in the



FIGS. 3-6. POINTS OF INTEREST AT THE DON PEDRO PLANT

Fig. 3. Oil circuit breaker room. Fig. 4. The Don Pedro dam under construction. Power house may be seen at the base of the dam. Fig. 5. Switchhouse and control board on the mezzanine floor in the generator room. Fig. 6. Generator room showing arrangement of transformers along wall.

bottom and crown plates, and are suspended by bronze thrust discs located under the operating levers. Cast-iron caps are bolted to the top of the gate stems to permit of adjusting gate clearance between the bottom and crown plates.

Each gate arm is connected to the shifting-ring by means of a link and two steel pins, one of each pair being slightly eccentric, thereby providing independent adjustment for each gate and insuring minimum leakage when in a closed position. The shifting ring is connected to a rocker shaft by two forged steel connecting rods, the rocker shaft, in turn, being connected to a servo motor by means of levers and links, one of said levers being provided with an adjustable crosshead operated by means of a hand-wheel and screw. With this arrangement the gate movement can be controlled within predetermined limits, with a constant servo motor stroke, under all operating heads. This device also automatically limits the discharge from the synchronous bypass, the connections to this bypass, however, being provided with an auxiliary adjusting mechanism that can be operated by hand, without in any way interfering with or interrupting the gate adjusting device.

Draft tubes are constructed so as to facilitate removal of the runner through a tunnel under the turbine floor. The main casting is of cast iron, of conical section, flanged on each end, and provided with a cored opening large enough to permit of removing the runner through it. There is a cover with a man-door attached, through which access can be had to the discharge end of the runner buckets for the purpose of inspection and cleaning them.

Braking apparatus consists of four asbestos-faced air rams, the bases of which are machine finished and bolted to machine finished pads on the generator spider casting. These brakes are designed to bring the generator rotor to rest within 5 min. after the turbine gates have been shut down and exciter current cut off.

Each turbine is provided with a 30,000-ft.-lb. fluid pressure governor which is of sufficient capacity to close the turbine gates from wide open position in 3 sec. The governor stand, with fly-balls, relay valve and regulating valve, and the hand-wheel for mechanical operation, are located on the generator floor, the operating cylinder of the governor being mounted on the spiral flume.

Governor connections to the turbine gates are so designed that it can be adjusted to limit the gate opening to that required for maximum output of 7000 hp. at any head, when using a full stroke of the governor. With this device it is unnecessary to disconnect the governor or shut down the unit while adjustment is taking place.

Each turbine is equipped with a special S. Morgan Smith synchronous bypass valve having a capacity of 50 per cent of the full discharge capacity of the turbine. The operating connections for this valve are arranged to move it in the reverse direction to the operation of the turbine gates. These connections are further designed to permit of adjusting the discharge by hand, to correspond with changes in governor connections, for changes in penstock heads. The bypass is designed to permit of disuse at seasons when it is desired to store surplus water in reservoir, and an inherent feature of the design prevents the possibility of quick changes in the bypass when disconnected from the governor.

An intermediate oil lubricated guide bearing is provided for each turbine shaft, the bearing being made in two parts to facilitate erection and dismantling it. Oil deflector and basin are provided for collecting and re-using the oil. A small rotary pump with piping leading from the basin to the top of the bearing insures a continuous circulation of the oil.

Draft Over the Fire

By E. M. Eliot

IF A boiler damper is left in a fixed position or an induced draft fan is operated at constant speed, without a damper, the draft over the fire will vary irregularly, depending on the pressure in the air chamber and the thickness of the fuel bed.

If the fuel bed becomes thin, when the forced draft is high, a plus pressure over the fire may result, in which case fire is forced out of the doors and peep holes of the boiler and high temperature gases may burn out soot blowers, sampling tubes or other devices auxiliary to the boiler. If the fuel bed becomes thick and the forced draft in the chamber low, the draft over the fire may go to 0.50 in. or more, i. e., there will be a strong suction tending to pull in excess air through the boiler setting, around doors and through every other neglected opening. This excess air must be heated, temperature of gases in the boiler will be lower, absorption of heat by the boiler tubes will be lower, and the flue gas temperature consequently higher.

Draft conditions over the fire will vary between the extremes described from hour to hour and even from minute to minute, unless some form of draft control is adopted. Under best conditions the draft should be as follows:

It should be high enough to remove the gases which rise from the fuel bed, and high enough so that extreme temperature does not fill every pocket in the boiler setting. It should not be a plus pressure, because of blowing fire into the boiler room and causing undue heating of the furnace lining, and it should be otherwise as low as possible, to avoid introduction of excess air. Experience shows this to be a draft between 0.05 in. and 0.08 in. of water except in the case of a poorly designed furnace when it may be somewhat higher. There are three methods of keeping a low constant draft over the fire.

1. Keeping the fireman continually at the damper.
2. Running all of the boilers on constant load except one, and taking the fluctuations on that one.
3. Mechanical regulation of the damper.

It is sometimes stated that high draft is needed to keep down temperatures in the boiler and to protect the boiler lining. If so, it is an indication of poor installation of the boiler, unless excessive overloads are being carried. In any case, it is very unsatisfactory, from the point of view of the boiler plant operator, to save his furnace linings by drawing in enough excess air to cool them. (That is what high draft over the fire does when it keeps the temperature down.) In nine cases out of ten, if the boiler plant operator will check the loss of fuel against the decreased life of the boiler linings, he will find that his draft is much too high, for most economical results.

Uniform Costs for Power Plants---IV

PREDETERMINATION OF RATES AND MONTHLY COMPARISON OF PLANT COSTS. BY ALFRED BARUCH.

IN DETERMINING cost of operation per unit, the indirect expense is the part most often ignored, or, at least, not given sufficient consideration. At the same time it is the part of the cost that will give most trouble. It is so elusive in character that it is likely to make the difference between profit and loss if it is not determined properly. Even when the indirect expense is known, it is often applied in the wrong way so that the costs arrived at are unfair to customers and competitors as well. There are many methods of applying the indirect expense to the cost but the problem is to find the right one for each industry. These methods are referred to as the blanket rate, the productive

DEPARTMENT	SUPPLIES			LABOR			BURDEN			TOTAL COST		COST PER KWH	
	QUAN.	PRICE	AM'T	UNIT	RATE	TOTAL	UNIT	RATE	TOTAL				
BOILER ROOM													
OPERATING													
INSTALLATION													
REPAIR													
METER													
TOTAL													
TOTAL LABOR													
TOTAL SUPPLIES													
TOTAL SELLING													
TOTAL COLLECTION													
TOTAL OFFICE													
TOTAL COMMERCIAL EXPENSE													
± PREDETERMINED RATE													
± PREDETERMINED RATE X KWH PRODUCED													
UNDER OR OVERABSORBED BURDEN													
TOTAL COMMERCIAL EXPENSE													
± PREDETERMINED RATE... % X PLANT OPERATION COST													
UNDER OR OVERABSORBED COMMERCIAL EXPENSE													
TOTAL REVENUE FOR MONTH													
LESS TOTAL COST													
OPERATING PROFIT FOR MONTH													

FORM FOR MONTHLY RECONCILIATION OF POWER PLANT COSTS

labor cost, productive labor hours, and the departmental or production center rate.

In actual practice, the blanket rate method is the one that is most often used. It makes the indirect expense, or burden, a proportion of the combined costs of labor and material such as coal and water, and assumes that the burden will rise and fall in proportion to the rise and fall of the cost of material and labor. In reality the burden is fairly constant while the price of coal fluctuates continually. This fact makes the method unsafe for practical purposes. A constant burden as based on variable material costs is always in danger of not being covered in the price. If the price of coal drops, showing a lower cost, the earning for burden will be less although the expenditures have been constant. A fall in the price of coal does not necessarily mean lessened demand. It may mean increased competition, just as well, or the introduction of labor-saving devices that lower the costs. These things are beyond the ordinary knowledge of the plant operator and he cannot base his burden upon the cost of material and labor if he is to be safe.

Productive labor cost is the second method. In a power plant it is rather difficult to determine which labor is productive and which is non-productive; but in general it is customary to classify the stokers, operators and repair men as productive labor. Since labor is constant in a power plant, this method is more equitable than the blanket rate method for the distribution of burden, but it too has objectionable features. In the boiler room, for example, one stoker may work faster or more efficiently than another one, consequently he can keep the steam at an even pressure with less consumption of coal and more production of power. This man is likely to be paid more for his services, but this method of distribution does not take the difference between men and their wages into account.

An even more accurate distribution may be brought about in the use of the productive hour method. The burden is based upon the time of the productive worker. Since the plant will be in operation every hour that productive workers are in attendance, this insures a charge for every hour at least.

All of the foregoing methods, however, have the objection that they make the burden a percentage of some other part of the cost. This is an inherited habit, which was developed in industries that convert their materials from one state into another, largely through the use of manual labor. But here the conversion of coal into heat energy and, later, into electrical energy, is accomplished by combustion and by machines, and the men are merely in attendance, contributing, in no way, to their skill or manipulation.

But basing the costs upon the units of the time of production, it is possible to get much nearer to actual costs than under any other method. For example, in the boiler room, the costs would be based on the number of pounds of steam or B.t.u. produced during the month. Each element of cost would be considered separately instead of making the burden a percentage.

Since the units of electrical energy are produced by machine, and not by men, it is necessary to connect all costs with machine effort, either on the basis of time that the machine operates or upon the basis of the number of units produced. That is, the cost is stated as a fixed amount for labor, water, and indirect expense per hour, or else it is stated as the fixed amount for labor, coal, water and indirect expenses per units of energy produced. Actually, these two bases are the same since the cost per unit depends upon the number of units that can be produced per hour, per day or per month.

Departmental or production center rates are used to isolate each department or production center as if it were a plant by itself. All costs that may be charged directly to it are identified by account numbers, indicating where they belong. Thus, the boiler room would be charged with coal, water, labor and indirect expenses, such as supplies and maintenance. The output would cost, per unit, the sum of all the expenses divided by the number of units produced, upon whatever basis it is decided to distribute the costs. The operating department would, in effect, buy this output from the boiler room and add to its original cost its own of production. In the case of the installation department, the cost could be based on the foot of line or cable erected or upon a plant unit such as the pole and all its accessories, making the cost of installation from pole to pole the the unit of measure. The repair department would use its machine at production centers and the costs of that

job going through on that basis, or upon the number of hours it takes each job to go through each machine. This discussion now brings us to a consideration of predetermined rates. The predetermined rate is the rate charged to each unit of production, or each job as it goes through a machine in the repair department. This rate is the standard that has been arrived at through investigation and experimentation and is charged to the unit of production regardless of actual costs at the time. This predetermined rate is the normal rate described in the first article. Because of variations in load, it is necessary to base the cost upon the average load rather than on the load at any one time. This average figure should be adopted after due allowance has been made for losses due to interruptions, breakdowns, and lower demands on the part of consumers. Once this rate is adopted, it may not be changed unless general conditions change to such an extent that a new rate is advisable.

The chief difference between the modern methods of managing a plant and the old one is that the modern operator knows where he stands much oftener than he did before, and in addition he has the various elements of his plant so analyzed that, when any department or production center is making unnecessary expenditures he can locate the difficulty almost at once and correct it. He does this through monthly reports which tell him of the profit or loss he has earned during the month on the plant, as a whole, on the individual departments and on the individual production centers. The profits or loss on the plant as a whole is made possible through the use of a monthly financial statement.

Departmental profit or loss is made possible through predetermined rates which, when multiplied by the number of units produced, show how much these units have earned during the month. This earning is compared with the actual expenses for the month, and if the latter exceeds the former a loss has been incurred. If the reverse is true, the department has made a profit. The source of information or labor costs is the file of daily time reports kept by the timekeeper. As they are automatically sorted by charge numbers, there is no difficulty in finding the labor cost for each department. The cost of coal and water is obtained from the original bill and the indirect expense is determined through the charge order number file system, already described.

The Monthly Comparison of Plant Costs

Reference is made above to the monthly comparison of plant costs. This is an itemized statement by departments of all the elements of cost such as labor, supplies, maintenance and apportioned expenses. In addition, a comparison is made for each of the above items with the standard costs for this department. The standard and the actual figures are placed side by side, and the increase or the decrease for the month is shown in the adjoining column. When the actual expenses has been determined, the predetermined rate per unit is multiplied by the number of units produced during the month and the result is compared with the actual expense of the department to see whether or not enough has been earned during the month to cover the department's expenses. For example, we will assume that the boiler department produced 35,000 lb. of steam during the last month at a cost of $38,000. If the standard cost is $35,000 for the same output, there is a loss of $3000 to be charged to this department.

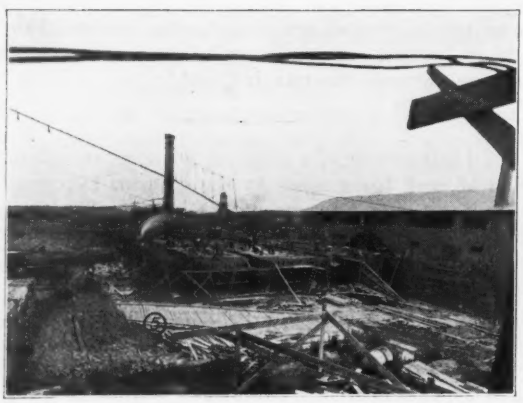
As indicated above, the cost statement is made once a month by listing all the expenses by departments; that is, the boiler room would have all the boiler room labor, supplies, maintenance and apportioned charges for the month listed and compared with the standard expenses for a month, the increase or decrease being noticed in each case. The totals of the sheets representing each department are then carried to a statement known as the Monthly Comparison of Plant Costs. This sheet shows the location of the plant, the date of the report, the department, the actual labor (alongside the standard for a month), the actual and standard supplies, maintenance, total cost and unit cost.

In making out this statement the totals of the individual departmental reports are entered against each department, and the total cost is obtained by adding all the labor, supplies, and maintenance for every department, and then totalling them. On the basis on the plant, as presupposed earlier in the discussion, this sheet would show the expenses for the boiler room, operating department, installation department, repair, meters department and commercial department. As the burden is charged directly in this case, it is possible to add all the expenses together and divide them by the number of units produced, to determine cost. In order to find the operating profit for the month, the revenue is calculated and the sum is subtracted from the total cost for the month, that is, the sum of the operating cost of all departments. The difference between the two is the operating profit.

The function of the various reports and records may be summarized as follows: The time reports furnish the basis for the payroll and determine the labor cost of operation. The consumption of materials and supplies of any sort is determined through requisition, weight, slip (in case of coal) and automatic recording devices (in case of water). As any expenditures come under the head of burden, it can be covered either by a material requisition or by a labor report. These two are brought together on the Monthly Comparison of Plant Cost, which, in turn, are summarized so as to show the individual items of expense, so that the standard and actual expenses may be compared and the difference between the two invested.

In the course of a study of the spontaneous combustion of coal, being made by the Interior Department at the Pittsburgh experiment station of the Bureau of Mines, J. D. Davis, chemist, and J. F. Byrne, research fellow, conducted experiments on spontaneous heating of coal starting from room temperature. Upper Freeport heated 3 deg. from room temperature in 6 hr. Upper Kittanning coal gave no heating whatever. This corresponds to results of practice. Kittanning coal is usually sold by dealers with a guarantee not to fire. It is semi-bituminous and similar to Pocahontas coal but not so firable. Pittsburgh coal rose a maximum of 2.7 deg. above room temperature in 72 hr. In these experiments, the coal was first treated in a current of coal gas to bring equilibrium with the thermostat, then a current of oxygen was passed through under adiabatic conditions. The apparatus seems to work satisfactory and the problem now resolves itself into finding the optimum rate of air or oxygen flow as a means of comparing the heating qualities of coals.

Building the World's Largest Generating Station



In the above photographs are shown views of preliminary developments in the construction of the new Crawford Avenue Generating Station of the Commonwealth Edison Co., Chicago. This plant, which will have an ultimate capacity of 600,000 kw., promises to be the largest generating station in the world. Photographs showing progress in the construction of this station will appear from time to time in Power Plant Engineering. Fig. 1 Excavating south end of property March 13. Fig. 2. General view of property, looking N. E., April 10. Fig. 3. Excavating, showing both sides of cut, May 9. Fig. 4. Removing spoil bank for outside sub-station, May 28. Fig. 5. Concrete forms for oil switch house, June 11. Fig. 6. Excavating spoil bank for sub-station, June 11. The switch house is the only part of the project which will be completed this year.

Economy Effected by Feed Water Heating

STUDIES OF LARGE PLANT INDICATE ADVANTAGE OF BLEEDING MAIN TURBINE IN PLANTS WITH AND WITHOUT ECONOMIZERS. BY G. G. BELL*

EFFECTS of feed water heating on plant economy were interestingly discussed in a paper presented by Linn Helander at the A. S. M. E. annual meeting, December, 1922. Mr. Helander has made a very complete study of the subject, and shows the theoretical relation between plants equipped with large and small house turbines, both with high boilers without economizers and medium-sized boilers with economizers.

In the spring of 1922 two more 30,000-kw. units were purchased for the Windsor station of the West Penn Power Co., Pittsburgh, Pa., the boiler-drum pressure was raised from 250 to 350 lb., and on account of this higher pressure steel-tube economizers were substituted for the

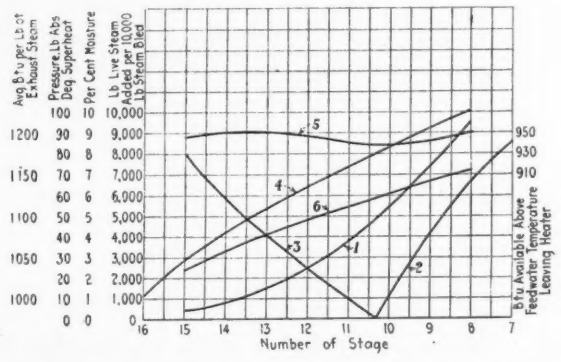


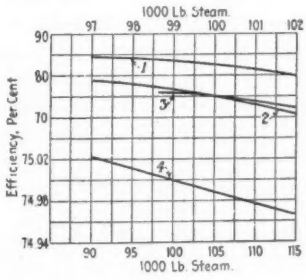
FIG. 1. DATA ON STEAM EXTRACTED FROM 30,000-KW. G. E. CURTIS TURBINE

(Steam condition, 300 lb., 200 deg., and 1 in. back pressure; load on turbine, 28,000 kw.
Curve 1—Absolute pressure at various stages.
Curve 2—Deg. superheat in steam bled from the various stages.
Curve 3—Percentage of moisture in bled steam.
Curve 4—Average B.t.u. per pound of bled steam.
Curve 5—B.t.u. available for heating feed water to maximum possible temperature by steam bled from any stage.
Curve 6—Number of pounds of live steam that must be added to permit extraction of 10,000 lb. of steam at various bleeding points.)

cast-iron economizer which had been installed with the first 16 boilers in the plant.

Troubles which other plants had had with corrosion in steel-tube economizers necessitated the installation of deaerating apparatus. Manufacturers of deaerating apparatus claimed that air separation was easier at temperatures above 160 deg. F. Experience with a closed system of feed water heating which prevented enrichment had maintained an average oxygen content in the feed water above 0.25 cc. per liter, provided the feed water temperature was maintained around 210 deg. F. Investigations of an existing plant equipped with economizers had indicated some advantages in increasing the feed water temperature to 210 deg. F. by utilizing the exhaust steam from a house turbine of sufficient size to supply the auxiliaries with power; although subsequent investigations have demonstrated that probably there would be a slightly higher saving if the study had been made for a temperature of 190 deg. instead of 210 deg.

In the new addition it was decided to heat the condensate by steam bled from the main unit instead of exhaust steam from the house turbine, and it was thought that the best temperature at which the feed water should enter the economizers should not be less than 210 deg. on account of the more efficient use of the steam in the main unit. To check this a study was made, as a result of which it was decided to heat the feed water to the highest



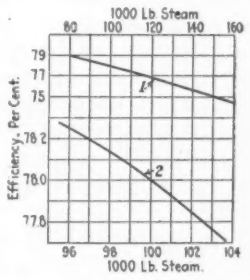


FIG. 2. EFFICIENCY OF 14 HIGH CROSS-DRUM B. & W. BOILER (8341 sq. ft. of steel economizer; steam pressure at drum, 325 lb.; temperature at superheater outlet, 225 deg. F.; feed water temperature, 210 deg. F.)

FIG. 3. EFFICIENCY OF 20 HIGH CROSS-DRUM B. & W. BOILER (No economizer; steam pressure at drum, 325 lb.; temperature at superheater outlet, 225 deg. F.; feed water temperature, 210 deg. F.)

temperature possible by extracting steam from the thirteenth stage.

Upon the preparation of Mr. Helander's paper, these studies were revised. Additional data on the turbine were obtained so as to give complete information for bleeding all stages from the eighth to the fifteenth, inclusive, and the effect on the economy of the station of single-, double- and triple-stage bleeding within these limits was studied. Data on steam extracted from the 30,000-kw. G. E. Curtis turbine at a load of 28,000-kw., steam conditions at throttle 300 lb., 200 deg., and 1 in. back pressure, are shown in Fig. 1.

In determining the temperature to which the feed water could be heated by each of the various stages, it was assumed that there was a loss between the turbine and the heater of 1 lb. when steam was extracted from the fifteenth stage, of 1½ lb. when extracted from the fourteenth stage, and 2 lb. when extracted from the thirteenth or any higher stage; and that in all cases the maximum temperature to which the feed water could be heated was 10 deg. lower than the temperature corresponding to the pressure of the steam at the heater.

Boilers purchased for Windsor are Babcock & Wilcox cross-drum type, 14 tubes high and 42 tubes wide, and are equipped with a slag screen and Babcock & Wilcox inclined baffle. The front headers are set 21 ft. above the floor, the drum center being 35 ft. 3 in. Four boilers are provided per unit, although it was assumed that when the turbine was operating at its point of best efficiency, which is 28,000 kw., three boilers would supply steam for the unit, the output of each boiler being about 100,000 lb. when feed water is supplied at a temperature of 210 deg. The extra boiler capacity would be utilized in reducing the rating on the boilers in the older section of the plant, which are not as efficient or as liberally stokered as the newer boilers.

*Abstract from a paper presented in the July, 1923, issue of Mechanical Engineering.

Figure 2 shows the efficiency of the new boiler and steel-tube economizer at various ratings. Curve 1 shows the combined efficiency of boiler and economizer; curve 2 the efficiency of the boiler alone, and curve 3 the boiler efficiency corrected for the effect of change in capacity on the efficiency of the economizer. Curve 4 is that portion of curve 3 which is used, amplified so as to permit of reading any slight variation in the relative efficiency of the boiler when operating at slight differences in output.

These figures are based upon 12 per cent CO_2. It is necessary in order to compare the results of bleeding from various stages to work to a fraction of one per cent. All computations were checked by the comptometer.

Figure 3 presents similar data for a 20-tube-high boiler without economizers. Curve 1 gives the efficiency of the boiler at various ratings, while curve 2 is that portion of curve 1 which is used, amplified so as to permit of reading any slight variation in the relative efficiency of the boiler when operating at slight differences in output.

In connection with the 14-tube-high boiler, 8341 sq. ft. steel economizers are installed. Table I gives the rise in the economizers when operating at a constant output of 100,000 lb. of steam per hour with feed water temperatures of 135, 170, 210, and 250 deg. The figures are derived from guarantees based on 210 deg. feed water and are proportional to the arithmetical mean of the temperature differences.

TABLE I. TEMPERATURE RISE IN ECONOMIZERS WHEN OPERATING AT A CONSTANT OUTPUT OF 100,000 LB. OF STEAM PER HOUR WITH VARIOUS FEED WATER TEMPERATURES

	Feed water temperatures, deg. F.			
	135	170	210	250
Gas temperature entering economizers, deg. F.	595	595	595	595
Gas temperature out of economizers, deg. F...	297	319	345	370
Drop in economizers, deg. F.....	298	276	250	225
Average gas temperature, deg. F.....	446	457	470	482.5
Water inlet to economizers, deg. F.....	135	170	210	250
Estimated rise in economizers, deg. F.....	128	118	107	96
Temperature of water leaving economizers, deg. F.	263	288	317	340
Average water temperature, deg. F.....	199	229	263.5	298
Average thermal difference in economizers, deg. F.	247	228	206.5	184.5
Rise in economizers, deg. F.....	128	118.4	107	95.8

The figures are derived from guarantees based on 210-deg. feed water and are proportional to the arithmetical mean of the temperature differences.

These results are plotted in Fig. 4, which also shows a comparison of single-extraction heating and heating the condensate by exhaust steam from a house turbine if the Windsor plant is equipped with a 14-tube-high boiler and 8341 sq. ft. economizers.

Curve 1 shows the heat consumption of the plant if the turbine is arranged for single-stage bleeding. These results are arrived at by calculating the heat requirements with bleeding at various stages from the tenth to fifteenth, and drawing a curve through the points thus obtained. The curve represents the results which might be obtained if the turbine were designed with an infinite number of stages and could be bled at any one of them. As a matter of practice these results can only be obtained when steam is bled from any one of the six stages coming within the limit of this curve and the feed water is heated as hot as possible by the steam extracted from the turbine.

Curve 2 shows the effect of bleeding from the thirteenth stage and throttling the amount of steam bled so as to get a varying temperature. This is practically a straight line. For the purpose of this study the condensate was assumed to be heated first approximately 20 deg. by the heat contained in the steam escaping from the steam seal. Twenty degrees is also the amount the condensate would be heated if before passing into the first bleeder heater it first cooled the generator air and then absorbed the heat in the bearing and transformer oil for the unit.

On curves 1 and 2 it was assumed that the boiler-feed pump was motor driven. If in place of a motor-driven boiler-feed pump a steam-driven pump is used, curve 3 will represent the heat requirements of the station. When sufficient steam is bled from the main unit to heat the feed water to the maximum obtainable from the thirteenth stage, the heat consumption in the plant equipped

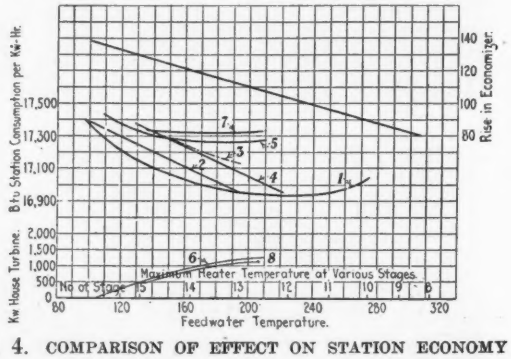


FIG. 4. COMPARISON OF EFFECT ON STATION ECONOMY OF HEATING FEED WATER BY EXHAUST STEAM, FROM HOUSE TURBINE, EFFICIENT DUPLEX-DRIVEN AUXILIARIES AND SINGLE STAGE EXTRACTION HEATING

(North extension of Windsor power station: 30,000-kw. G. E. turbines, 28,000-kw. load; 14 high cross-drum B. & W. boilers; induced draft; 60 per cent economizer; steam conditions at throttle, 300 lb., 200 deg. F., 1 in. back pressure.)

with a motor-driven pump is approximately 1 per cent less than in one provided with a steam-turbine-driven pump. This is when the exhaust steam from the steam-driven boiler-feed pump is discharged into the same heater as the steam bled from the main unit. When using a steam-driven boiler-feed pump the minimum temperature increased from 97.5 to 127.5 deg. F.

Curve 4 shows the results if steam from the boiler-feed pump is discharged to a separate heater and used to heat the feed water sufficiently above the temperature of the feed water leaving the extraction heater to get the necessary re-evaporation to permit the deaerator to function satisfactorily. Where the pressure will permit, the exhaust steam from the turbine glands is discharged into the same condenser as the exhaust steam from the boiler-feed pump. The curve indicates that approximately the same results can be obtained by using the turbine-driven pump as with the motor-driven pump, provided that separate heaters are used and the feed water is heated approximately 25 deg. above that used with a motor-driven-boiler-feed pump.

Curve 5 shows the results which would be obtained if the feed water were heated by exhaust steam from a house turbine. Guarantees were obtained on house turbines designed for three different back pressures, and in figuring this curve the steam consumption used in each

case would apply only if a special house turbine were designed for the operating conditions under consideration. This curve indicates that there is very little difference in the economy of using a house turbine in connection with the 14-tube-high boiler and 60 per cent economizer with feed water temperatures between 170 and 190 deg. Assuming that this house turbine had been bought for a back pressure corresponding to 180 deg., if the feed water temperature were then varied by increasing or decreasing the output from the house turbine, the heat requirements of the plant over the range would be higher than shown in curve 5, and would only coincide with that curve when using a feed water temperature of 180 deg., the point for which this particular turbine was designed.

Curve 6 shows the amount of power which can be obtained from the house turbines when heating the feed water to the temperatures shown in curve 5.

TABLE II. WATER RATE FOR VARIOUS FEED WATER TEMPERATURES

Final feed water temperature, deg. F.	Back pressure on turbine exhaust, lb. per sq in.	Water rate, lb. per brake hp.-hr.
135	4.56	16.5
170	7.99	17.0
210	16.13	21.0

Curve 7 shows the results which would be obtained if the feed water were heated by exhaust steam from efficient high speed geared turbines driving the auxiliaries. In this case one design of turbine is used and operated with various back pressures, so that full advantage is not taken of the increase in vacuum which it is possible to get with the lower feed water temperature. The water rate for various feed water temperatures is given in Table II. The curve indicates that within the range of the temperatures under consideration there is practically no difference in the heat requirements of the plant, although if the small geared sets were so designed as to show an increase in economy with a decrease in back pressure, it would pay to lower the feed water temperature to the lowest point that was practicable and still prevent the sweating of the economizer tubes.

Curve 8 shows the amount of power generated by the geared turbine driven sets. The reason that curves 5 and 7 approach each other at the lower temperatures is that the house turbine is of larger capacity and at low feed water temperatures is operated at part loads, whereas in curve 7 it is assumed that only enough of the gear driven units are run to give the required temperature when each turbine is carrying the maximum load.

Figure 5 shows a comparison of results on the Windsor plant if the turbine were arranged for single-, double- or triple-stage extraction heating and the plant equipped with 14-tube-high boilers and 8341 sq. ft. economizers.

Curve 1 shows the heat consumption of a plant arranged for single-stage bleeding at any of the temperatures within the limits of the curve. This curve is the same as curve 1 of Fig. 4 and shows best results at a feed water temperature of 225 deg. F., with a very slight increase in heat requirements by increasing or decreasing the feed water temperature 25 or 30 deg.

Curve 2 shows the heat consumption of a plant arranged for bleeding from the fourteenth and a higher stage.

Curve 3 shows the heat consumption when bleeding from the thirteenth stage and a higher stage.

Curve 2 shows that minimum heat requirements are obtained by a combination of the fourteenth and twelfth or eleventh stages at a temperature of 225 or 251 deg. F.

Curve 4 shows that the best results with triple-stage heating are obtained with a combination of the fourteenth, twelfth, and tenth stages, the best results being obtained at a temperature of 275 deg. F.

Curve 5 shows the heat consumption with triple-stage heating using the fourteenth, eleventh, and a higher stage. This combination is not as efficient as that shown in curve 4.

These studies are all made for a plant operated with a motor driven boiler-feed pump. They indicate that there is very little difference between bleeding the eleventh, twelfth, or the thirteenth stage with single-stage

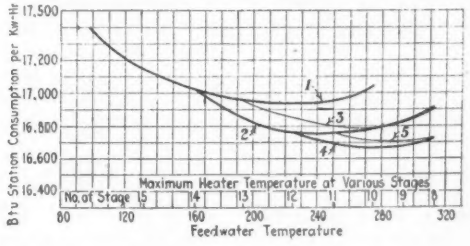


FIG. 5. EFFECT OF SINGLE-, DOUBLE- AND TRIPLE-STAGE EXTRACTION HEATING ON FEED WATER TEMPERATURE AND STATION ECONOMY

(North extension of Windsor power station: 30,000-kw. G. E. turbines, 28,000-kw. load; steam conditions at throttle, 300 lb., 200 deg. F. and 1 in. back pressure; 14 high cross-drum B. & W. boiler; 60 per cent economizer; induced draft.)

heating; and that for double-stage heating a combination of the fourteenth and twelfth or eleventh stages gives the best result, the heat requirements per net kilowatt-hour being about 16,750 as against 16,940 B.t.u. for single-stage heating. In triple-stage heating a combination of the fourteenth, twelfth, and tenth stages gives the best results, the heat requirements for triple-stage bleeding being about 16,600 B.t.u. as compared with 16,750 B.t.u. for the double-stage heating and 16,940 B.t.u. for single-stage heating.

While there are a number of points to consider in obtaining plant requirements, the work can be reduced to a comparatively simple form; and with a set of curves as those in Fig. 1 which give information for various stages and temperatures, etc., a point can be determined every twenty minutes by using a slide rule; however, a slide rule is not accurate enough to give smooth curves.

Figure 6 is a study of single-, double- and triple-stage heating for the Windsor turbines, in combination with a 20-tube-high boiler having an efficiency of about 78 per cent at the point at which it is operated.

Curve 1 shows the results obtained with single-stage bleeding.

Curves 2 and 3 show the results obtained with double-stage heating. There is apparently very little difference whether the thirteenth or fourteenth stage is used as the first stage.

Curve 5 shows the results obtained with triple-stage heating, the best being those obtained by a combination of the fourteenth, eleventh, and eighth stages. It is pos-

sible that a higher stage might be slightly more efficient, but the data therefor were not available.

Figure 7 is a comparison of the results of the Windsor study. Mr. Helander limited his study to four stages, but the curve is projected so as to show the approximate results for five stages. The Windsor study was made for

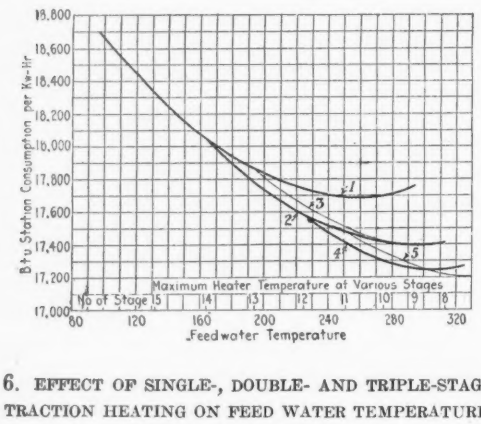


FIG. 6. EFFECT OF SINGLE-, DOUBLE- AND TRIPLE-STAGE EXTRACTION HEATING ON FEED WATER TEMPERATURE AND STATION ECONOMY

(North extension of Windsor power station: 30,000-kw. G. E. turbines, 28,000-kw load; steam conditions at throttle, 300 lb., 200 deg. and 1 in. back pressure; 20 high cross-drum B. & W. boilers; no economizer; natural draft.)

three stages, but is extended so as to indicate the approximate results for four stages.

Figure 8 shows the temperature at which the best results were obtained for single-, double- and triple-stage bleeding in the Windsor study and single-, double- and quadruple-stage bleeding in the Helander study.

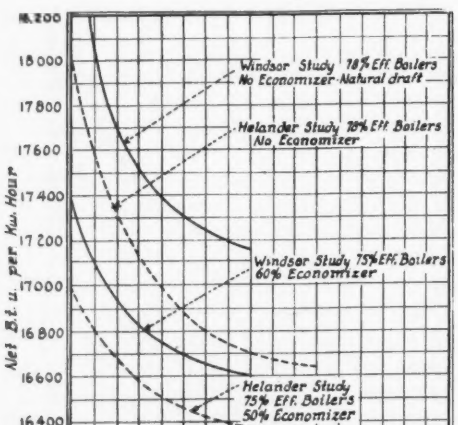

Windsor Study 78% Eff. Boilers No Economizer-Natural draft
Helander Study 78% Eff. Boilers No Economizer
Windsor Study 75% Eff. Boilers 60% Economizer
Helander Study 75% Eff. Boilers 50% Economizer
Net B.t.u. per Kw. Hour
Number of Stage Heaters

FIG. 7. COMPARISON OF WINDSOR AND HELANDER STUDIES OF EFFECT OF VARIOUS STAGE BLEEDING ON POWER STATION ECONOMY

These studies clearly indicate the advantage of bleeding the main unit with or without economizers, as there is a gain of 1.10 per cent for double-stage over single-stage heating and approximately one-half that amount if triple-stage is used in place of double-stage heating, that is, for a 14-tube-high boiler equipped with economizer; whereas for a 20-tube-high boiler there is a gain of 1.64 per cent in double-stage heating over single-stage, and about 1.00 per cent if triple-stage heating is used in place of double-stage.

Regarding reliability, while the heater condensers will complicate the condensate piping and increase the pumping head, with the possible exception of the effect of breakage of extraction heater tubes, it is difficult to see how they will affect the reliability of the plant or complicate the operating problems. The breakage of a condenser tube can be taken care of either by installing check valves between the heater and the main unit, or in the lower-stage heaters by putting in drip lines of large enough capacity to take care of possible leakage. Condensate that leaks through a broken tube in this way is returned to the condenser or condensate system, and is not lost. Gate valves should be installed between the

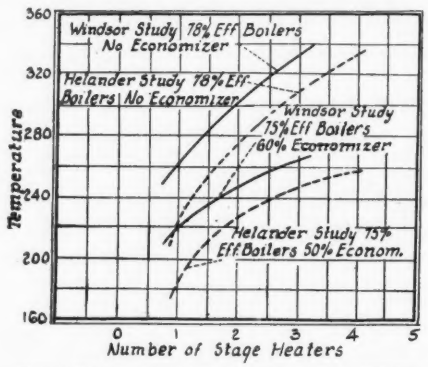

Windsor Study 78% Eff. Boilers No Economizer
Helander Study 78% Eff. Boilers No Economizer
Windsor Study 75% Eff. Boilers 60% Economizer
Helander Study 75% Eff. Boilers 50% Econom.
Temperature
Number of Stage Heaters

FIG. 8. COMPARISON OF WINDSOR AND HELANDER STUDIES SHOWING THE TEMPERATURE AT WHICH THE BEST RESULTS ARE OBTAINED FOR VARIOUS STAGE BLEEDING

heater and the main unit so that the heater can be disconnected from the unit if desired.

Regarding the capacity of condensing equipment, as the bleeding of the main unit reduces the amount of heat passing to the main condenser, some reduction in its size is permissible. Figure 9 shows the pounds of vapor and condensed steam entering the main condenser per hour for various bleeding combinations. This study indicates that for single-stage bleeding the condenser capacity need only be 93 per cent of that required if steam is bled from the main unit. For double-stage heating this ratio becomes 91 per cent and for triple-stage heating 90 per cent.

Figure 4 indicates that heating the feed water by exhaust steam from the house turbine is much less efficient than by bleeding the main unit; there is an advantage of approximately 1.85 per cent in favor of bleeding the main unit. This has led to a change in the type of house turbine installed. The tendency seems to be to carry only as much load on the house turbine as is necessary for the sake of reliability, paralleling the house turbine with the main unit and carrying all the load on the main unit, the switch being so arranged that in case of a heavy overload on the system, the house turbine with certain auxiliaries, will pull away from the main unit and the house turbine will carry these auxiliaries at a slightly lower frequency until such time as the load can be again picked up by the main unit. The latest proposition is to carry no load on the house turbine but have it running so as to be able to pick up the necessary auxiliaries in case of trouble to the main unit.

With this latter arrangement it is proposed to run a small pipe from the exhaust end of the house turbine to the condenser of the main unit, a check valve being placed in the main exhaust pipe from the main unit, maintaining in this way a rarefied medium for the rotor to spin in, so that it will not overheat when running idle. The vacuum required in the exhaust end of the house turbine to prevent overheating varies with the design of the house turbine. It is only with the most efficient types of turbine that there is any danger that the vacuum which it is possible to maintain in the exhaust end of the house turbine will not be high enough during the warm summer months. The losses of such a standby house turbine when running in a high vacuum are very small.

It is possible to heat the condensate about 13 deg. by using the condensate to cool the air in a closed generator cooling system; and a rise of 7 deg. more may be obtained by absorbing the heat in the transformer and turbine oil. The use of condensate in these cooling coils will keep them clean; but there is some slight complication in re-

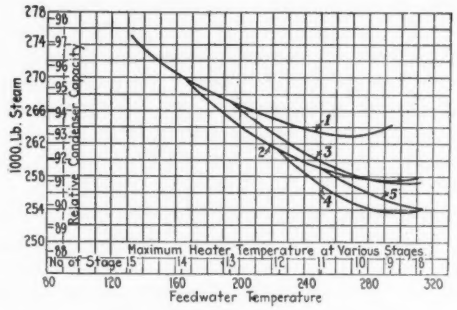


FIG. 9. AMOUNT OF STEAM PASSING TO MAIN CONDENSER AND RELATIVE SIZE OF MAIN CONDENSER REQUIRED

gard to the operation of such a system during the warm summer months, or in case of dropping of load by the main unit. This latter is probably only important in case the transformers and turbine are not paralleled as a unit on the high side of the transformers but paralleled with the other units on the low side.

These transformers will stand an interruption in the cooling water supply for several minutes without injurious effect. In studying such a system and comparing the reduction in heat requirements, consideration must be given to the fact that by absorbing this waste heat the amount of steam which can be bled from the main unit is reduced; and while there is a possible reduction in the heat requirements of the plant of 1¾ per cent by absorbing the waste heat, if additional steam is bled from the thirteenth stage of the main unit the heat requirements will be about 136 B.t.u. per net kilowatt-hour higher than if the condensate temperature is raised by the waste heat in the generator air and transformer and turbine oil or the net gain in station economy of absorbing this waste heat is about eight-tenths of one per cent.

WE ARE ALL FOOLS at times, and in work of accident prevention we should go upon the theory that all people are fools all of the time.—E. L. Elliott, at Eleventh Safety Congress.

Power Losses Due to Bending*

By W. F. Schaphorst

IT IS OFTEN claimed that power is wasted through the bending of a line shaft—that power is lost in doing such bending.

It is easy to prove that where the elastic limit of a shaft is not reached and where the shaft or metal returns to its original position, the amount of energy given up while going back to the original position is practically the same as the energy given to it in bending it out of shape. A watch spring, for example, is continually expanding and contracting. It runs smoothly from one extreme to the other, carrying with it a balance wheel. Even when the watch is not wound up, the balance wheel will oscillate several times after receiving one push. In the same way a tuning fork, when struck, will hum for a long time because the prong of the fork moves backward and forward very rapidly, alternately giving up and absorbing energy.

In the same way a line shaft that is bent within the elastic limit wastes practically no power due to the internal bending. According to my way of looking at it, most of the power that is lost is due to the increased pressure against the bearings or the "binding action" caused by the bending of the shaft. If the elastic limit of the shaft is passed, the shaft will not long endure. It will become hot and will soon break.

I have never known a shaft to increase perceptibly in temperature due to the bending action. If there is any increase in temperature, it is almost invariably caused by external friction and not by internal friction. The fact that there is no increase in temperature proves to my mind that the power absorbed by bending is practically nil. One way to discover where the waste power is going is to go around and feel the shaft at various places, or feel the pulleys. Wherever there is abnormal friction there is bound to be heat, whether in the shaft or on the pulleys. If a belt on a pulley slips excessively it will generate heat and the temperature often goes high enough so that it can easily be detected with the fingers through the sense of touch.

POWER PLANT equipment and supplies are in good demand in the district around Bergen, Norway, according to a report to the Department of Commerce from Consul George Nicolas Ifft. In the districts of More, Sogn og Fjordene and Hordland, there are 664 power stations with a total generating capacity of 279,885 kilowatts. During the year 1922, 52 new stations were installed. Supplies for these stations are imported from Germany, Sweden, England and the United States. Equipment is also manufactured locally at the Norwegian plants of two German companies and one American concern. Although German houses have been dominant in this trade, the situation has so changed recently that there now appears to be an excellent opportunity for American manufacturers to secure a good share of the available business.

NO MAN receives so much for his money as he who employs a competent engineer, regardless of the rate of pay.

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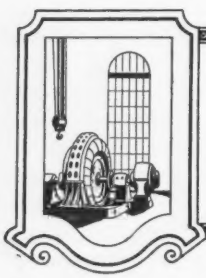


ELECTRICAL MACHINERY FOR LIGHT AND POWER

Transmission-Line Load-Distribution Factors---I

PROCEDURE FOR DETERMINING THE NET POWER DEMAND OF ANY FAIRLY EXTENSIVE LOCAL DISTRIBUTION SYSTEM. BY E. K. McDOWELL*

ONE OF THE FIRST operations involved in the electrical design of any transmission or feeder circuit is to determine the load at the receiving end; i.e. the total kilowatts of delivered power. In the various published works on the design of power lines this receiving-end load is generally referred to as one of the line constants; i.e. as known, or given, data; but in practice it generally has to be fixed by whoever is responsible for the line calculations. The problem is relatively simple when the connected load consists of only a few motors, or other load-units, which situation may obtain on some feeder and motor branch circuits; but more often the receiving-end conditions are more complex, especially on main transmission lines and the more important distribution feeders.

More or less off-hand estimation of the load may suffice for some of the first-mentioned classes of circuits, but for the longer and more important main transmissions and feeders the load conditions are generally such that some definite and logical procedure will be necessary in estimating the receiving-end load; otherwise the results will, in many cases, be little better than guess work.

This becomes evident when we consider the general extent of circuits treated in this series of articles. Calculation methods are developed herein for the electrical design of what is known as "short" transmission lines; which may include circuits up to around 33,000 v.

Evidently, many of these circuits will supply power to quite extensive load-distribution systems. In such cases the load conditions are likely to be highly diversified and complex; but someone has to analyze the situation and determine what the net kilowatt demand will be that has to be supplied by the transmission line.

LOAD DISTRIBUTION FACTORS IN GENERAL

To facilitate load estimation of this character it will be attempted, in these articles, to outline suitable procedure for determining the net kw. power demand of any fairly extensive local distribution system, such as industrial and miscellaneous combined lighting and power, commercial and residence lighting, etc. About the only way that this can be handled both conveniently and systematically is by the use of certain load-distribution factors as will be outlined under succeeding headings.

The total power demand on a transmission line supplying a distribution system of any extent will generally be considerably less than the total of the maximum demands of all the power-consumers connected to the system. This is partly due to the fact that, at any given time, some of the motors, lighting groups, etc., are generally shut down or are very lightly loaded; also maximum demands do not, as a rule, occur simultaneously on all of these load-units. Also, for similar reasons, the demand on any one service transformer bank is generally considerably less than the total rated connected load served thereby. It is now necessary to estimate a total kilowatt of power, to be delivered by the transmission line, which will be adequate (but not unnecessarily excessive) to meet these diversified demands.

In engineering studies of load distribution, in connection with large public-service systems, it has been customary to take account of the general conditions just referred to by the use of certain factors (or rather groups of factors), certain of which can be employed to advantage for estimating the total power to be delivered by a proposed transmission line, when an extensive distribution system is supplied thereby. Those that will be employed in this connection are (1) demand factors, (2) diversity factors, and (3) what will be termed herein total-demand factors. Associated in a general way with those factors are some others that have to do mainly with rate-making and economic considerations such as load factors and connected-load factors.

All of these load-distribution factors are, in general, determined by local conditions; and definite values therefor, applicable to a given system, can only be ascertained by extended tests made on that system. Nevertheless, values ascertained for portions of one system can be applied, for approximate results, to other systems where similar conditions prevail. Also, approximate values of the proper factors can be assumed, on the same general basis, for use when designing new installations; or when "tying in" to existing systems where it is impracticable to make tests. The nature and specific application of these factors will be outlined further later on, also typical values will be given for various conditions. At this point, however, it is necessary to give some preliminary explanation relative to the special significance of the term Maximum Demand.

This term, as used in connection with load-distribution factors, denotes the greatest average power-load over a relatively short interval, such as 15 min. or 30 min., and should properly be stated as "max. 15-min. demand" or "max. 30-min. demand." That is, the

*Chief Engineer, Donora Steel Works, American Steel & Wire Co.

"max. 15-min. demand" on any certain system or part of a system is the greatest average power-load for a 15-min. interval that occurred during a relatively long period, such as a day, a month, or a year. It is not the greatest "instantaneous peak" load that occurred during such interval and should not be confused therewith, but is the average power during the one 15-min. interval for which said average is the greatest during, say, a month or a year.

Maximum demand is generally expressed in kilowatts and is most conveniently determined by (so-called) maximum-demand meters, these instruments being arranged to "average" and record automatically the average power demand over each successive 15-min. or 30-min. interval. Both of these intervals are widely used, also 5-min. and 10-min. intervals are occasionally employed, the present tendency being, apparently, to use the 15-min. interval. When the term "maximum demand" is used hereinafter, without qualification, it will be understood that the 15-min. demand is implied.

The 15-min. or 30-min. interval basis for maximum demand arises in connection with the use, sometimes made, of maximum demand values for determining what capacity of generators it is necessary to install in order to supply power to a specified total capacity of connected load apparatus. Since practically all generators will carry overloads of 50 per cent or greater momentarily, it is therefore neither necessary nor economical to provide generating capacity for carrying continuously a total kilowatt of load that will only be imposed for very short intervals. However, a maximum load continuing for 15 to 30 min. should not exceed the continuous load capacity of the generator by any considerable amount, else the machine will be seriously overheated and probably damaged.

This, therefore, establishes the maximum demand during some such interval as 15 or 30 min. as a suitable basis upon which to fix the capacity of generators, and likewise of any other electrical apparatus needed to supply a given connected load. As will be seen later, demand factors and diversity factors are determined from max. demand values; therefore these particular load distribution factors can be regarded, in a general way, as simply being convenient means for utilizing maximum demand values to determine the aggregate net demand of extensive and diversified distribution systems.

Demand Factor

This is a ratio, expressed in per cent, equal to the maximum demand (of a whole load-group) divided by the total rated connected load of that group; or, expressed as an equation.

$$\text{Demand factor} = \frac{\text{max. (15-min. or 30-min.) demand, in Kw.}}{\text{total connected load (reduced to Kw.)}} \qquad (13)$$

The total connected load is, of course, determined by adding up the nominal (or manufacturer's) ratings of all the motors, lamps, or other power-consumers included in the given load-group; ratings given in horsepower being converted into kilowatt equivalent ($= \text{hp} \times .746$). The max. demand, when ascertained definitely for an existing installation, will generally be determined by use of a demand-meter; but can also be determined (less conveniently) from a graphic wattmeter chart, or by an ammeter.

The principal use of the demand factor is, as regards this discussion, for arriving at the max. demand (in kilowatts) of any certain load-group; when the connected load is known, as in case of a proposed installation or a proposed addition to an existing load-group. For such purposes it is customary to assume an appropriate value for the demand factor, basing the assumption upon values determined for other installations of the same general character and that are known to have similar load conditions. The max. demand is then estimated, approximately, by applying equation (13) in an inverted form, viz:

$$\text{Max. Demand (in kilowatts)} = \text{tot. kilowatts of conn. load} \times \text{demand factor} \qquad (14)$$

In assuming demand-factor values, careful consideration should be given to the various special load-conditions that may obtain in particular instances; especially in connection with industrial load. When available, use demand-factor values that, it is known, have been determined from other installations of the same class and that are known to have similar load-characteristics. For many proposed installations it will be necessary to make a more or less independent assumption of demand-factor value; basing this only on what may be known, in a general way, as to the expected load-conditions. Values from published tables of demand factors can be used, in a broad way, for guidance in such cases; with the understanding that such data represents, generally, average values based on tests of a number of installations; and that local load-characteristics can, in particular instances, cause the actual demand-factor to differ widely from any average value gotten from such tables. A few typical average values, for certain frequently-encountered classes of load, are given in the accompanying table, but these figures should be applied very conservatively, and with the understanding that data of this sort is, at best, an indifferent substitute for actual demand-factor values determined by test on installations known to be similar to the particular case for which a value is to be assumed.

Conditions Affecting Demand-Factor Value

The following matter refers especially to fairly extensive load-groups such as the entire connected load of a medium-sized manufacturing plant; e.g., a textile mill, machine shop, flour mill, or wood-working establishment; in general, any industrial load-group supplied from one service transformer bank.

At any given instant there will generally be some of the motors, or part or all of the lamps of the lighting system that are either shut down or are operated under light load. Also, if some of the motors are subject to varying or intermittent service (e.g., cranes, hoists, certain machine tools, etc.), maximum or "peak" loads will seldom occur coincidently on all or on any considerable number of these units. Furthermore, it is a common tendency to install motors more or less oversize for any given load, and some of the motors may be underloaded on this account.

The maximum demand of such an installation will, therefore, be less than the total connected load in nearly all cases; accordingly the demand factor (max. load divided by connected load) will usually be less than

unity. The extent to which this obtains will depend upon the particular load conditions in any given case. Generally speaking, however, the demand factor will be higher (nearer unity) for installations where nearly all the motors operate continuously and at fairly constant load; and will be relatively lower where the nature of the work requires frequent shutting down of a number of the motors, where only a portion of the motor-driven machinery is in use at any one time, or where many of the motors are subject to varying and intermittent loads.

Considerable difference may obtain, however, in demand factors for the same general class of load as between different individual plants. This can result from a number of differing local conditions such as one plant having a greater number of motors than another, hence more "diversity" of load between them; or one plant having crane and hoist, elevator, or other intermittent loads predominating to a greater degree than another plant. Also, conditions at one plant may be such that some of the larger motors are usually shut down during the time of day when the maximum demand occurs; or there may be general business conditions that are different between two otherwise similar establishments, resulting in more constant operation of the motor-driven machinery of one plant than obtains for the other one, where the equipment may be the same but the production requirements may be lighter. Similarly, the demand factor of a large works can be reduced by distributing the operations of certain departments more or less equally over the 24 hours instead of operating these departments day turn only, as might be customary at other similar plants. This has been done, in certain cases, by concerns using purchased power in order to reduce the demand charge therefor.

Lighting load demand factors are reasonably constant for any certain classes of buildings served, but may be relatively high, frequently greater than unity, for residence load. This is due to the extensive use of portable heating appliances, electric fans, and the like, which did not, ordinarily, get counted in on the connected load. Residence load is, however, highly diversified, and it is seldom that the maximum demands of more than a few of the consumers on one service transformer occur coincidently. For this reason demand factor values for apartment buildings are relatively low, a rough average being about 60 per cent.

TABLE I. TYPICAL VALUES OF DEMAND FACTORS FOR MISCELLANEOUS POWER AND LIGHTING CONSUMERS

Group ref. No.	Class of Consumer	No. of cons'rs in av.	Demand Factor max.	Demand Factor min.	Demand Factor av.	Kw conn. load and remarks
Col. No.	(1)	(2)	(3)	(4)	(5)	(6)
	Commercial and Lighting: (Above 65 kw. conn. load.) Department Stores	6	.53	.35	.40	Incl. 4 largest stores in Chicago. (1917)
	do (Marshall-Field)	1	.45	.36	.40	
	do	1	.45	.35	.38	1770 kw.
	Office Bldgs. (large)	3	.58	.....	.50	700 kw. av.
(a)	Commercial, Lighting and Miscellaneous Power: (Below 65 kw. conn. load.) Dept. Stores (small, outlying)	6	.56	.....	.87	56 kw. av.
	Small Stores (in resid. dist.)	9	1.0	.....	.82	7.5 kw. av.
	Moving Picture Theatres	4	.78	.....	.53	57 kw. av.
	Apart. Bldgs. (9 to 36 apts. ea.)	8	.81	.....	.63	34.4 kw. av.
	do (6 apts. ea.)	10	.72	.....	.64	12.8 kw. av.
	do (3 apts. ea.)	5	.82	.....	.60	7 kw. av.
	Residences	26	1.2*	.....	.65	Av. 2 kw. ea., not including heating appliances.*
	Small Machine Shops	8	.62	.....	.44	
	Miscellaneous Power: (Above 65 kw. conn. load) Struc. Steel fabricating Shops.	2	.32	.10	.24	885&1350 kw.
	Machine Shops (misc.)	4	.62	.....	.50	386 kw. av.
(b)	Machine Shop and Drop-forge plant	1	.50	.40	.45	1000 kw.
	Foundries	5	.72	.....	.41	316 kw. av.
	Refrigerating Plant (ice mfg.)	10	1.1	**	.81	300 kw. av.

**Due to the highly competitive nature of the ice machinery business, ammonia compressor motors are commonly installed very close to the actual load in rated capacity. Overloads occur during the heavy business and humid weather in July and August.

Note:—Groups (a) and (b) data is from "Feeder Sizes and Conn. Load," by H. B. Gear, in "Elect. Review and Western Electrician" (now the "Industrial Engineer") ***

(c) Bituminous Coal Mining: (Small and med. installations)	Demand Factor: If Continuous load.	Demand Factor: If intermittent load.
1—Motor	.80	.54
2—Motors	.72	.48
3 to 5 motors	.68	.46
6 to 10 motors	.64	.43
11 or more motors	.60	.40

Note:—This group (c) data is based on "Tables for Estimating Consumers Maximum Demand" by W. W. Arnett, Jr.; published in the "Electrical World" (May 21, 9121 issue). These factors were used by the Monon. Traction Co., Fairmont, W. Va., for estimating the maximum demand of miscellaneous coal mining installations, for use in figuring consumers demand charges. This was done temporarily, until demand meters could be installed. Average results are said to have checked quite closely with subsequent metered demands; although a few individual cases differed widely. (Data used here by permission of the "Electrical World".)

***Data used here by permission of the "Industrial Engineer," formerly the "Electrical Review & Western Electrician."

Typical Average Values of Demand Factors

Typical average values of demand factors are given in the accompanying Table I for a number of different classes of commercial and medium-sized industrial power and lighting load. These values have been selected mainly from such published material as is available, which pertains mostly to commercial and miscellaneous power and lighting installations of medium size. Those associated with public service companies can obtain, probably, more extensive and more recent data of this character from their own records. For individuals having to do with industrial power projects, however, it is frequently difficult to locate such information, and Table I is intended mainly for this class of users and for illustrative purposes.

Table I values can be used as a general basis when assuming demand-factor values for proposed installations, additions to existing load, etc., where no first-hand data of this sort is available. The assumed value should be increased above the corresponding table value in some cases where load conditions can be foreseen that are related to relatively high demand factor, and can perhaps be decreased in other cases where opposite conditions are expected. The range of maximum-minimum average values given, for certain classes of load, will give some indication of what latitude is appropriate in this connection.

Factors in groups (d) to (f) inclusive, were compiled in 1909 by E. W. Lloyd from the records of a large number of consumers of the Commonwealth Edison Company of Chicago. The values for lighting consumers (groups d and e) should probably be materially increased to conform to present-day conditions, since there is considerable evidence to show that the demands of at least the smaller lighting consumers have materially increased during the past ten years.

However, the work of compiling such figures as these involves studying the records of thousands of users;

and these studies made in 1909 do not appear to have been repeated by anyone. Accordingly there is little else available in the way of published data on this subject. With regard to power users, such as the classes listed in group (f), the Commonwealth Edison Co. advise, through H. B. Gear, that they believe these 1909 factors to be still reasonably reliable, since the general factory methods have not changed so greatly as has the use of electric lighting.

Demand factor values of groups (a) and (b) are of more recent date, having been compiled and published by Mr. Gear in 1917. They are based on demand-meter records of a limited number of consumers of each class named, the number of installations represented in each average being indicated in Col. 2 of the table. The average kilowatt connected load per consumer is also shown, where available, in Col. 6.

Group (h) factors have been collected from various first-hand sources in connection with steel and blast furnace plants.

Diversity, General Nature of

As used in connection with distribution systems the term "diversity" is used specifically to signify "diversity of demand"; i.e., to indicate that the maximum demands of different consumers, or of different subdivisions of a system, are not coincident. For instance, the demand for power purposes is generally greatest at a time of the day when the demand for lighting is small. Also, in the case of lighting load, certain consumers—such as department stores and manufacturing establishments—will impose a maximum demand during the day, while the maximum demand for some other classes of lighting load, such as drug stores, residences, apartment buildings, etc., will occur mainly in the evening. A similar condition obtains among manufacturing and general power users, the maximum demands of many of these occurring at different times in the day. This general situation is also affected by seasonal conditions, since some consumers, such as refrigerating plants, amusement parks, quarries, etc., will impose little or no demand during the winter months, at which time general lighting load and some of the power load may show a maximum demand.

As a general result of these conditions, the maximum demand on a feeder supplying a number of service transformers is less than the sum of the maximum demands on these transformers; also the maximum demand on a substation, supplying a number of such feeders, is less than the sum of the maximum demands on the several feeders. Similarly, the maximum demand on a main transmission line is less than the sum of the maximum demands of all the substations supplied therefrom. These conditions are taken into account by the use of diversity factors.

Diversity Factors

As used in these articles, a diversity factor is the maximum coincident demand of a number of services (or co-ordinate parts of a system) divided by the sum of the individual maximum demands of these services, or parts of the system, the result being expressed as a percentage. For reasons explained above, a diversity factor (as thus defined) is generally less than unity, although if the maximum demands of all of the services occurred simultaneously the factor would equal unity. This may occur among certain classes of consumers, but is unusual.

Conditions Affecting Diversity Factor

Like demand factors, these diversity factor values are largely determined by local conditions. On feeders where the power load predominates, the diversity factor will differ from those on which lighting load predominates; similarly, the diversity factor among feeders or among substations in a retail commercial hotel or theater district will differ from similar factors for a residence district or for a manufacturing district.

Diversity factors can only be ascertained definitely by maximum demand tests on the various individual services or consumers, together with similar maximum demand determinations on the feeder, substation bus, or transmission line supplying the various individual services, feeders or substations. However, as was the case with demand factors, if diversity factors are determined for certain general conditions on one system or part of a system, these factors can be applied, for approximate estimation of the aggregate demand, on other systems where the load conditions are known to be similar.

TABLE I (CONTINUED)

Group ref. No.	Class of Consumer	No. of cons'rs in av.	Demand Factor			Kw. conn. load and remarks
Col. No.	(1)	(2)	max. (3)	min. (4)	av. (5)	(6)
(d)	Commercial and Lighting: (Small and med. consumers.)					
	Hotels (small) and rooming houses	66	.....	.....	.67	.....
	Churches	15	.....	.....	.56	.....
	Hospitals	34	.....	.....	.42	.....
	Schools	78	.....	.....	.53	.....
	Banks, also business and professional offices	5367*	.....	.....	.65	*100 banks in av. balance is offices.
	Barber Shops	443	.....	.....	.70	.....
	Billiard and pool roms, also cigar stores	323	.....	.....	.65	.....
	Drug Stores	831	.....	.....	.79	.....
	Stores: grocery, furniture and dry goods	1026	.....	.....	.73	.....
	Stationery and book, shoe, and jewelers	703	.....	.....	.65	.....
	Clothing, also tailor shops	756	.....	.....	.56	.....
	Hardware, also warehouses and wholesale houses	469	.....	.....	.43	.....
(e)	Commercial and Lighting: (Misc. large consumers.)					
	Hotels (large)	.....	.....	.....	.40	.....
	Theatres, also large restaurants	.....	.....	.....	.60	.....
	R. R. Depots	.....	.....	.....	.50	.....
	Post Offices	.....	.....	.....	.30	.....
(f)	Industrial and Miscellaneous combined Power and Light: (Large consumers.)					
	Power and loft buildings	.....	.....	.....	.40	.....
	Clothing manufacturers	.....	.....	.....	.55	.....
	Furniture manufacturers and miscellaneous wood-working	.....	.....	.....	.65	.....
	Textile mills, also shoe mfg	.....	.....	.....	.65	.....
	Woolen Mills	.....	.....	.....	.80	.....
	Laundries, also sheet-metal mfg	.....	.....	.....	.70	.....
	Newspaper printing	.....	.....	.....	.75	.....
	Miscellaneous Engraving and Printing establishments	.....	.....	.....	.60	.....
	Grain Elevators, also Packing Houses	.....	.....	.....	.75	.....
(g)	County, Federal and Municip. Bldgs.	.....	.....	.....	.35	.....
	Universities and Colleges	.....	.....	.....	.30	.....
	Theatres (small)	.....	.....	.....	.75	.....
	Restaurants, also Lodge and Dance Halls	.....	.....	.....	.70	.....
	Sign, outline, display and window lighting	.....	.....	.....	1.0	.....

Note:—Groups (d), (e) and (f) factors are based on tables by E. W. Lloyd, in a paper entitled "Compilation of Load Factors," appearing in the Proceedings of the National Electric Light Association, 1909.

Group (g) factors are quoted from an article by J. R. Cravath, entitled "Demand and Diversity Factors," in the "Electrical World" issue of Sept. 8th, 1910; used here by permission of that publication. They were originally compiled by the Wisconsin R. R. & Public Service Commission, from demand meter records of several power companies.

Something of this sort has to be done in practice for the reason that practically no extensive studies of diversity have been made since 1909, at which time H. B. Gear, then engineer of distribution for the Commonwealth Edison Co. of Chicago, made extended studies

TABLE I (CONTINUED)

Group ref. No.	Class of Consumer	No. of plants or groups in av.	Demand Factor	Kw. conn. load, date, and remarks
	Industrial and Misc. (steel and blast furnace plants, departments of): Pumping Station.....	1	.83	1500 kw. (yr. 1921). Five motor-driven centrif. pumps. Total cap'y 35 million gals. per 24 hrs.
	Flue-Dust Sintering Plant (Dwight-Lloyd process.)	1	.93	320 kw. (yr. 1922) av. output 250-T/da.
(h)	Slag-Crushing and Screening Plant..... (Large modern plant.)	1	.25	267 kw. (yr. 1922). Daily cap'y 2500-T (10 hrs.) of product.
	Locomotive and Car Repair Shop.....	1	.25	400 kw. (app'x) (yr. 1920).
	Rolling-Mill Main Drive Motors..... (* 5-min. max. demand.)	6**	.77*	av. 1350 h.p. ea. motor. max. 2600 h.p. ea. motor. min. 600 h.p. ea. motor.

Note:—(**). This includes certain of the larger mill drive motors in a large elect.-driven hot-rolled strip mill; the demand factor given being the average of individual demand factors for six mill-drive motors. Three of these were DC motors, supplied from a fly-wheel M-G set; the metered demand being the input to this M-G set. These were 600 and 800 h.p. motors driving individual stands of a continuous mill. The other three motors were 6600v and 2200v AC slip-ring induction type. One of these was somewhat overloaded (demand factor—1.12). These tests were made in 1920.

Note:—(*). The average 15-min. demand factor would be lower than this figure; which is based on 5-min. demand measurements; also the aggregate demand-factor for all six motors would be less, since the above is the average of non-coincident demand-factors; and is intended simply as a typical demand-factor value for a single mill-drive motor.

This compares well with a rough average figure of .75, which was given by one of the leading manufacturers of this class of equipment, as a demand-factor that could be applied in case of a single non-reversing mill-drive motor, for approximate estimates of power demand.

of diversity on the lines of that system. The results of these studies are recorded in Mr. Gear's book "Electric Central Station Distribution Systems" (1916, pp. 354-369 incl.); to which the reader can refer for a very complete discussion of the whole subject of "Diversity."

General Classification of Diversity Factors

General Classification of Diversity Factors is best made on the basis of the different branches or co-ordinate parts of a system that are supplied from a common source. Thus each of the following classes of diversity factors applies, at the point in the system named, to the several subdivisions supplied from that point; and the conditions determining each class are more or less independent. However, the remarks under the preceding heading relative to differences in factors for different localities, districts, etc., apply in a broad sense to each of the following classes. There are, then, different sets or classes of diversity factors as

(1) between individual consumers, the diversity factor being taken at the service transformer from which all the given consumers are supplied.

(2) between service transformers, as at the feeder supplying these transformers.

(3) between distribution feeders, as at the substaton bus or other common supply point for the particular set of feeders considered.

(4) between substations as at the main transmission line which supplies the several substations.

Also, ultimately,

(5) between main transmission lines as at the central station, or other main distributing point, from which these several transmission lines radiate.

The maximum demand at any point in the preceding classification is, from definition of the diversity factor, equal to the sum of the maximum demands of the parts or subdivisions supplied therefrom multiplied by the diversity factor among these parts. Thus the maximum demand on a service transformer supplying several consumers equals the sum of the maximum demands of all the consumers supplied therefrom multiplied by the diversity factor applying among these consumers.

Likewise, the maximum demand on a distribution feeder equals the sum of the maximum demands on service transformers multiplied by the diversity factor among service transformers; and the maximum demand on a sub-station equals the sum of these demands on feeders multiplied by the diversity factor among feeders. Finally, the maximum demand on the transmission line equals the sum of the sub-station demands, multiplied by the diversity factor among sub-stations.

This determines the total power demand or total kilowatt of power to be delivered by the transmission line which is the immediate object of all the foregoing procedure and discussion of distribution factors, as related to the design of transmission circuits. In the next section of this article we will take up the application of load distribution factors.

Duplication of Electrical Equipment in Stations*

Local Conditions Will Have a Determining Influence Upon Degree of Duplication Necessary. By William F. Sims

IN ORDER to provide against serious interruptions to service, adequate safeguards must be provided in the installation of electrical equipment in generating stations. Also, to permit equipment to be taken out of service for inspection and repair without interfering with the continuity of the service, certain portions of the apparatus and connections must be duplicated. To what extent duplication should be carried is one of the important questions that concern central station design.

Importance and the character of the service given have a direct bearing on this question, and in stations of large metropolitan systems it is of course necessary to provide against interruptions to a much greater extent than would be the case in smaller and less important stations. In determining how far these provisions should be carried, the probability of trouble and the value of the added safeguards and extra apparatus required must be carefully balanced against the greater cost of installation and the increased complications that may be involved in the design. Simplicity of operation should always be striven for.

Experience in the design and operation of large stations shows that certain features of this nature are of the greatest importance. The arrangement of busses is one of these and it requires most careful consideration. The bus layout should provide for two sets of main busses, preferably connected through reactors with pro-

* Paper presented at the Annual Convention of the A. I. E. E., Swampscott, Mass., June 26 to 29, 1923.

vision for connecting any generator to either bus and each bus sectionalized so that trouble may be isolated; or else it should be a ring bus system with sections connected through reactors. In either case the installation of reactors of the requisite value to limit the short-circuit current in any section to an amount within the safe rupturing capacity of the switching equipment is essential to safe operation.

An isolated phase arrangement of the busses in the switch house, which eliminates the danger of phase-to-phase short circuits within the station, together with generator neutral resistances of such value as to limit the current to ground to a reasonable amount, affords a high degree of safety. In stations of large capacity this arrangement is particularly desirable.

In addition to the foregoing, an amount of duplication of bus construction sufficient to enable any part of the installation to be disconnected from the system for inspection or repair, without interfering with service, is necessary. Groupings of lines on separate line busses, which may, as a unit be connected to either of two main busses, is an effective form of duplication that is commonly used. With parallel lines to the same substation connected to different line busses, a very flexible arrangement may be secured without unduly increasing the number of switches. The installation of current-limiting reactors on all outgoing lines is now recognized as necessary to reduce the effects of short circuits due to cable breakdowns. A further safeguard, in addition to an adequate system of relays on the lines themselves, is the installation of relays with a long time setting on the group switches between the main busses and the line busses.

All practical precautions should be taken to prevent any interruption to the supply of energy to the control system. The use of a storage battery of ample capacity with duplicate charging sets gives a high degree of reliability and freedom from interruption. The control system should be well sectionalized to permit the necessary testing and the isolation of any portion that has developed a ground or other trouble. Important parts of this system should be duplicated and throw over switches provided. Particular care should be given to its design and installation, and it should be so installed that it will be able to withstand a test of at least 1500 v. to ground.

As the reliability of the excitation system is one of the most important conditions required, duplication of supply and thorough safeguarding of the system are necessary. If shaft-driven exciters are used, some form of reserve excitation, with throw-over switches to it should be provided. This reserve may be a separate exciter, a battery, or both. As shaft driven exciters are usually designed with an extra factor of safety, both mechanical and electrical, the comparatively high additional investment in reserve excitation storage battery may not be warranted. In such cases, it is the practice to connect the operating bus battery so that it may, in emergency, be used for excitation. When this is done, the battery should be of sufficient capacity to carry the load of the control system and the excitation of the largest generator in the station without exceeding its normal one-hour discharge rate. If the excitation is obtained from separately driven exciters, a total capacity of exciters sufficient for supplying the excitation of all units, with one spare exciter, will be required. Duplicate exciter busses are necessary with this system to insure adequate reliability.

Temperature detectors imbedded in the generator windings, with suitable indicating and recording instruments are a very important safeguard. The number of these to be installed in a generator should include extra detectors for use in case any of the others become open-circuited. The installation of duplicate synchroscopes is extremely desirable, as it is necessary to be able to synchronize at any time.

Of particular importance is the safeguarding of the auxiliaries, which are now so largely electrically driven, as the operation of the main units is absolutely dependent upon the continuous service of certain of these auxiliaries. Any reasonable amount of duplication and safeguarding required to obtain this condition is not only justified, but necessary. Reliability of the source of supply is the first requisite, but the same degree of "standard practice" has not as yet been reached in the installation of the auxiliary power system as has been the case in other parts of station design. A house generator, which is not affected by system trouble, would afford a high degree of reliability of supply. If connected in parallel with transformers fed from the station bus, with a dependable method of automatically throwing the essential auxiliary motors to either source, in the event of trouble on the other, the chance of failure of supply is reduced to a minimum.

If a house generator is not used, it is necessary to depend upon supply from the station busses through transformers. In addition to the number of transformers necessary to carry the station auxiliary load, an additional transformer of each voltage should be installed, ready for immediate use in the event of a burnout of any of the others. In order to minimize the effect of system trouble, a method of connecting the source of supply for the auxiliary transformers to each of the main busses, with reactors between each bus and the point of connection, has been used. The effect of trouble on either bus section is then less liable to lower the voltage of the auxiliary power system to a value that would seriously affect the operation of the motors. A system of relays designed to disconnect the auxiliary systems from the bus section that may be in trouble is an essential feature of this scheme.

Duplication and sectionalizing of auxiliary power busses, with throw-over switches in the motor services, or emergency services to which the motors could be connected when trouble occurs on this part of the auxiliary system, would insure reasonable reliability of service.

In conclusion, the degree of refinement to which duplication and safeguarding should be carried, depends to some extent upon the circumstances existing in each individual case. The features which have been discussed should all be taken into account and modified as may be necessary to meet local conditions.

TO DEVELOP team work and a sense of responsibility in members of an organization, and to secure progress in effectiveness and economy, it is essential to have records of performance, to compare those records both for individuals and for groups, and to show the effect of the activity of each person and group on the final result in cost and output.

Auxiliary Power Supplied from Three Sources

House Turbine, House Transformers and Motor Generator Set to Be Used in New Hudson Avenue Station

IN THE Hudson Avenue station now being built by the Brooklyn Edison Co., rather unusual attention has been given to the problem of assuring an uninterrupted current supply for the motor driven auxiliaries.

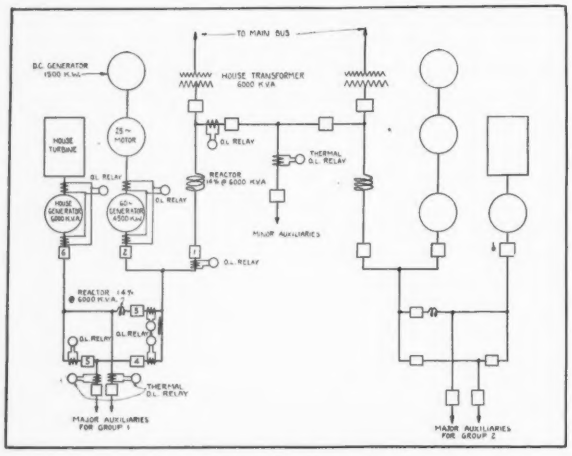


FIG. 1. EACH GROUP OF TWO MAIN UNITS WILL HAVE ITS OWN AUXILIARY POWER SERVICE SUPPLIED FROM THREE SOURCES

Besides the combination of a house transformer and house turbine supply for each group of two generators, there will be a supplemental outside supply provided through a frequency changer set from the 25-cycle Gold St. station.

This frequency changer set is to be induction motor driven and will normally be operated at synchronous speed by its generator acting as a lightly loaded synchronous motor and as synchronous condenser on the house service bus. A 1500-kw. direct current generator for supplying current to stoker, clinker roll and forced draft fan motors is also a part of this set and furnishes the load when the set is driven with the alternating current generator operating as a synchronous motor.

In addition to the method of supplying current from three sources, careful attention has been given to the bus arrangement and relay protection scheme. The major auxiliaries are supplied from two busses, one-half being connected to bus A and one-half to bus B. These two busses are supplied at one end by the 6000-kv.a. transformer bank taking current from the main bus and also from the induction motor synchronous generator set. At the other end, the busses are supplied by a 4500-kw. house turbine with a 6000-kv.a. generator. This generator is good for 6000 kv.a. at 0 per cent power factor.

All sets have differential relay protection and the worst that can happen through trouble to any one of the three is the loss of one-half of the auxiliaries, leaving two sources of supply connected to the bus. Reactances are installed before and after the transformer

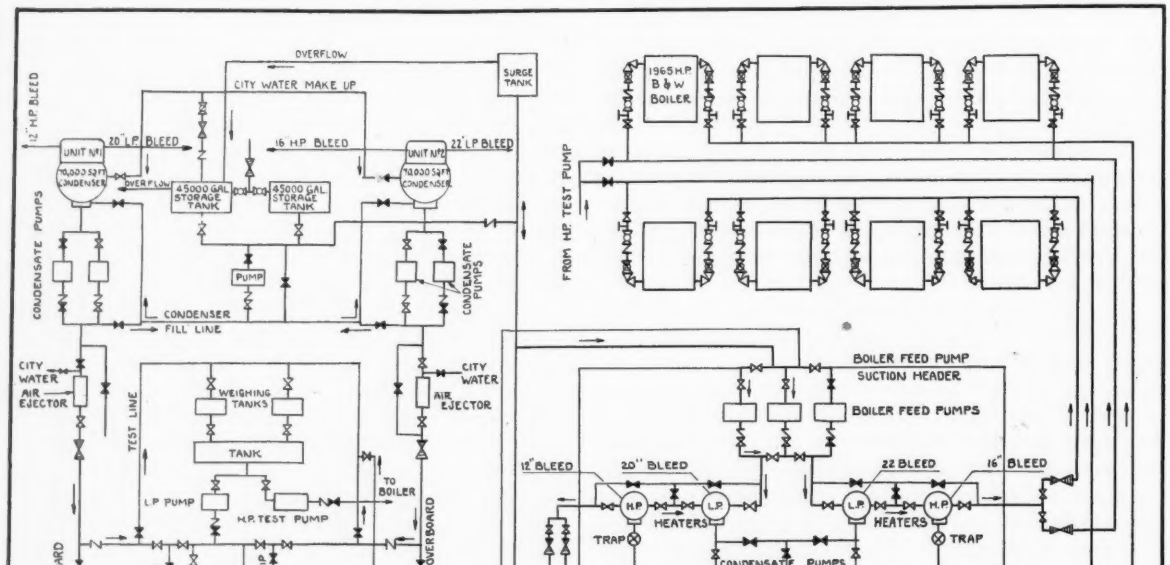


FIG. 2. HOUSE TURBINE PLAYS MINOR PART IN THIS HEAT BALANCE SCHEME

bank and a quite high reactance on bus A next to switch 3.

Under normal operation, switch 5 is to be left open and the synchronous induction motor set will float on the line, taking no current from the 25-cycle system to which it is connected but with the synchronous machine running as a condenser, connecting the power factor and also driving the direct current generator.

With this method of driving the auxiliaries, the house turbine is of no particular value in the heat balance scheme. In fact, the economy of the station will be better with the house turbine shut down, its use being justified only as an additional source of auxiliary power and for starting up the station. If, when adding future units to station it is desired to dispense with additional house turbines, this may be done without affecting the heat balance.

With this arrangement, boiler feed water may be heated from four different sources:

1. From the high pressure bleed point of main turbine, this point delivering bleed steam at an average pressure of 150 lb. absolute.

2. From the low pressure bleed point of main turbine, this point delivering bleed steam at an average pressure of 15 lb. absolute.

3. The inter and after cooler for air ejectors on condenser for main turbine.

4. The house turbine condenser.

Condensate is pumped from the two main condensers through the house alternator condenser with a surge tank into which the make-up water is fed, floating on the inlet side of this condenser. From the house condenser the water goes to the suctions of the boiler feed pumps. The discharge from the boiler feed pumps divides and goes through two closed heaters which take bleeder steam from a low pressure point on the two main units. The water then passes through two other closed heaters which are supplied with steam from a higher pressure point on the two main units. From the second closed heater the water passes to a single pipe supplying the boilers.

It was found that two-stage bleeding gave 0.5 per cent better thermal efficiency than one high pressure bleed. Three-stage bleeding would have resulted in 0.2 per cent better thermal efficiency than the two-stage bleed. This latter was not warranted by the extra complications and piping.

General plans for this station were presented on page 177 of the February 1 issue of Power Plant Engineering. The station will be divided into four groups of two units each. The initial capacity will be made up of two 50,000-kw. turbines and it is reported that a third unit has also been ordered. The ultimate capacity of the station will be from 400,000 to 500,000 kw.

Cylinder Wear in Oil Engines

HIGH CYLINDER PRESSURES AND SIDE THRUST CAUSES OF RAPID WEAR. BY M. S. HOWARD.

THERE is much controversy and speculation as to the length of service to be expected from the cylinder of an oil engine. The excessive wear observed in certain engines is likewise a source of worry both to the owner and operator.

Rate of wear to be expected from an engine in good working condition should be somewhere between 20,000 and 40,000 hr. If an engine cylinder has a life of 25,000 hr. before reboring is necessary, the engineer has every right to feel that he is above reproach.

Those who are more familiar with steam engines than with oil engines will probably be surprised at the life of the cylinder just mentioned. Steam engines often are run for years without enough wear to justify reboring, and a life as short as 5 yr. would be alarming. The steam engine, however, works with fairly low pressures, i.e., less than 200 lb. per sq. in. as a rule, and the tendency of leakage by the piston is not so great as where pressures up to 500 lb. are used. For this reason, piston clearances in a high grade steam engine of around 18-in. bore would be somewhere about 1/32 or 0.030 in., while a Diesel piston of like diameter would have a clearance of 0.007 in. The difference in clearance values indicates the difference in the tendency of piston leakage. It should be understood that while the piston rings do the work of sealing the clearance the leakage depends upon the piston clearance, for even a well-fitting ring will not prevent leakage when the piston clearance is large. It follows that while a piston wear of 0.007 in. for the steam engine piston increases the clearances only 23 per cent, in the oil engine the same wear doubles the clearance.

There is still another reason for the shorter life of the oil engine piston. The side pressure on the trunk type oil engine piston is considerable since the piston must bear the vertical component of the cylinder pressure. In the steam engine the crosshead shoe experiences this side pressure and the piston has only a slight side thrust. The extent of the side thrust of the oil engine piston may be seen by a study of the indicator card in Fig. 1. If the rod is four times the piston stroke, at the point A where the fuel injection ends and the pressure is 500 lb., the total cylinder pressure in an 18-in. bore cylinder is 127,300 lb. The side thrust when the piston is at A is about 14,000 lb. If the crank has a 20-in. travel, the piston will be around 36 in. long. The projected area is $36 \times 18 = 648$ in., which makes the thrust almost 22 lb. per sq. in. However, Diesel pistons are almost always tapered so that the top one-third does not touch the cylinder, while the body is relieved at the piston pin ends. The side pressure then runs as high as 50 lb. per sq. in. When one considers that this is a sliding pressure repeated as often as 400 times a minute, high cylinder wear is not surprising.

In engines where the rings are made extra stiff or the grooves filled with carbon, the side thrust may all be borne by the six piston rings, bringing the pressure up to several hundred pounds per square inch.

Side thrust on the cylinder walls at any point in the stroke may be found by the method of resolution of forces outlined in Fig. 2. Suppose a force of 100 lb. is acting in the direction of AB and a force of 100 lb. is acting in the direction of CD. These forces may be represented by lines whose lengths are proportional

to the forces and whose directions are the directions in which the forces are acting. Laying these lengths off, from A′, we have A′B′ and A′C′. If a mass is acted upon by these forces, the mass will tend to move in a horizontal direction along A′B′ and vertically in the direction AC′ and the resultant motion due to the application of these two forces will be along the path C′B′, the force in this direction being equal to the

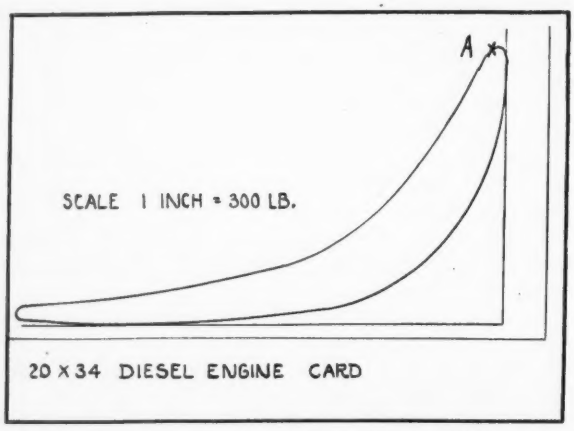
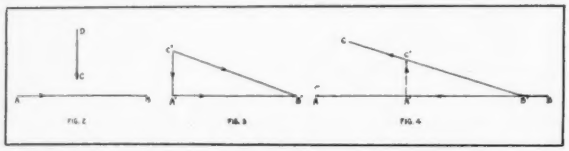


FIG. 1. POINT A REPRESENTS A PRESSURE OF 500 LB. PER SQ. IN.; TOTAL PRESSURE OF 127,300 LB. OF WHICH 14,000 LB. IS SIDE THRUST COMPONENT

length C′B′. In other words, the two forces are resolved into a single force proportional to C′B′ and in the direction C′B′.

Conversely having a force equal to C′B′ this force may be resolved into two components acting at right angles to each other. If the direction of one of these components is known, the direction of the other being at right angles is found at once and the value of the two component forces found. This is shown in Fig. 4, where we have a force proportional to B′C′ and with



FIGS. 2 TO 4. METHOD OF RESOLVING FORCES INTO TOTAL FORCE AND INTO COMPONENTS

a direction along BC. If one of the components is in the direction BA, by drawing the line C′A′ the two forces are found to be represented by C′A′ and A′B′.

Likewise if we know the direction BC but not its amount, but know the value B′A′ and direction BA of one of the components, we can find the amount of the force B′C′ as well as the value of the component A′C′.

In an engine there is a force acting along the connecting rod causing the crankpin to turn. At any position of the crank as in Fig. 5, the direction of the connecting rod force is along the rod, but its amount is not known; however, we can find the value of the force acting along the axis of the cylinder and exerting pressure on the piston by measuring the pressure at this piston position from the indicator card. The force acting along the rod may then be found by dropping a line from the rod to the cylinder axis line as shown in Fig. 5 where AB is made to represent the total pressure on the piston when the rod is in the position shown. This pressure is of course 0.7854 d^2P where d is the cylinder diameter and P the pressure in pounds per square inch. The force along the rod is then BC. The force at right angles to the cylinder axis is AC and represents the side thrust R on the cylinder wall.

In Fig. 6 are shown the crank circle and an indicator card. If the dimensions are made on the same scale as the indicator card it is possible to find the side pressure R for any piston position. In Fig. 6 when the crank is at OX the piston is at X. The pressure on the piston at this point is represented by the

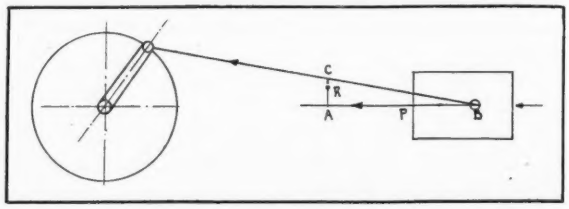


FIG. 5. SIDE THRUST VARIES WITH THE POSITION OF THE PISTON

length XZ on the indicator card. Lay this out along the base line and call it P or XA. Draw a vertical line from A to the connecting rod at C; AC or R is the side thrust. Next measure this and multiply it by the indicator scale and by 0.7854 d^2 to give the total side pressure in pounds.

This has been done for a number of points in the stroke and the value of the side thrust laid out as shown in the lower part of Fig. 6.

An examination of Fig. 6 will show why the cylinder always wears at the top or cylinder end. Here the pressure is high and the sudden increase of pressure

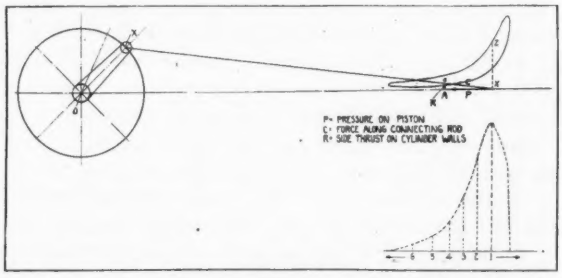


FIG. 6. METHOD USED IN DETERMINING THE SIDE THRUST AT VARIOUS POINTS IN THE STROKE

throws the piston to the side. The top ring then bears heavily on the cylinder walls and in time wears a ridge. There may be as many as three of these rings along the cylinder.

Sometimes it is possible to explain the mystery of broken piston rings through the existence of these sharp ridges. It is usual to find only the top ring broken, and engineers think this trouble is due to carbon settling behind the rings or to poor ring metal.

Often the ridges cause repeated ring trouble and appear to demand a new liner. The ridges may be dressed down with an emery stone, and although the top ring may leak a little gas the liner will still give

a lot of service. Only when secondary ridges appear between the old ones is a new liner necessary.

Just how much clearance can exist and still allow the engine to work satisfactorily is largely a question of power. If the engine is carrying up to its full load a clearance of 0.040 in. is as much as should be permitted. On the other hand if the engine is carrying less than one-half load the wear may be as large as 1/8 in. and still allow the engine to operate, although the fuel consumption will increase a slight amount.

Rate of wear varies; for example, one engine after 3 yr. operation showed a wear equal to about 0.0025 in. per 1000 hr. of service. When wear is enough to require replacement the question of method comes up. Should the liner be rebored and an oversized piston purchased, or should the worn piston be turned down to make it true and a new liner of proper bore purchased? Since the piston is always cheaper than the liner, which is twice as long, the cheaper thing is to rebore the old liner and buy an oversize piston. The reboring should be done by mechanics thoroughly familiar with such work. The job of centering the boring bar is not child's play and giving the tool the proper feed is a matter of seasoned judgment.

Steam Cylinder Lubrication*---III

Determination of the Proper Lubricant and Statement of Facts of General Applicability

ONE OF THE most important characteristics of a cylinder oil is the viscosity. Oils of low viscosity atomize more readily than those of high viscosity. On the other hand, they also evaporate more rapidly from the cylinder walls. Conversely, although high viscosity oils require higher steam temperatures for atomization, they remain on the cylinder walls for a longer time. Other things being equal, it is generally advisable to use the heaviest bodied oils that will atomize completely under the operating conditions. Incomplete atomization, however, is a greater drawback than too light an oil. This is especially true in the case of superheated steam. While the preceding statement as to heavy bodied oils is generally true there are many cases, particularly with low temperature steam, where it is practical to use a lower viscosity oil and still prevent metal to metal contact. This, of course, is desirable as it reduces friction losses. This use of a lighter oil is particularly adapted to vertical engines where friction pressures are small and the principal function of the oil is to form a seal. In fact, some vertical engines run with only water lubrication. In high speed engines also friction losses due to the use of an oil of too high viscosity may more than offset the gain in evaporation made by the use of such oil, and hence a lighter oil is to be preferred.

Where steam is dirty, it may be advisable to use a low viscosity oil, as in this case impurities do not stick as tightly to the exposed surfaces and hence are more easily washed away. Usually when steam is dirty it is also wet, and the temperature is not high, so that a low viscosity oil will have sufficient body under working conditions to prevent metallic contact.

Amount of Compounding

In regard to the proper amount of compound to use in an oil, it can be said axiomatically that no more should be used than is necessary in order to maintain a film of oil on the cylinder walls. The present-day tendency is more and more to reduce the quantity of compound but to improve its quality. Primarily, compounded oils are used to take care of wet steam conditions. As, except on rare occasions, there is always wet steam at some part of the system, compounded oils should always be used unless there are conditions where such use will cause more trouble than will be compensated for by the gain or economy produced. Such a condition exists where the condensed steam is re-used in the boiler, or where it is used for ice making or for heating. That tendency in compounded oils which causes them to unite with water to form emulsions in the cylinders, also prevents them from separating readily from water in condensed steam; also the more completely atomized the oil is, the more difficult it is to separate from water.

Oil in the form of fine emulsions in a boiler combines with the boiler compounds to cause foaming, or with the boiler impurities to produce a coating over the tubes and fire surfaces. This coating seems to form more readily over clean tubes than over dirty ones. A very thin layer of oily sludge over a fire surface will so insulate it that there is not only a large loss in heat efficiency but the rise in temperature of the metal may be so excessive as to cause the burning out or explosion of the boiler. Even if the exhaust steam is used only for heating, the heaters become coated with the oil and lose in efficiency. This is also true if exhaust steam is used in feed water heaters. If the engines are of the condensing type, the oil, unless removed, will form layers on the condenser tubes with a consequent loss in power. It is necessary, therefore, in all cases where the condensed steam is used over again, to separate the oil from it.

Oil Separators

There are many types of oil separators designed to be used either before the steam goes to the condenser or before it is fit to be pumped back into the boiler, either in whole or in part. These generally depend upon the principle of slowing the velocity of the steam so that the oil may settle down, or by causing steam to impinge upon a series of surfaces which collect the oil and drain it away from the steam. One type of separator collects the oil by spraying a small quantity of hot water into the steam before it goes to the condenser. This coalesces the oil particles so they can be segregated. In addition to these, it is generally necessary to have some filtering system before the oil is carried back into the boiler. With high vacuum the velocity of the steam may be so great as to render separation of the oil difficult.

Another factor which may determine the best viscosity of the cylinder oil to use is the type of packing. A soft packing, on account of the pressure usually employed to make it tight, requires a fairly viscous oil to lubricate it without loss of power. A metallic packing,

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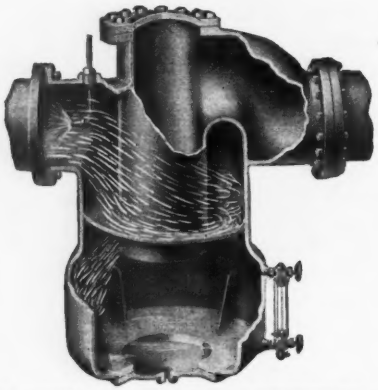
on the other hand, can be so designed that there is very little pressure against the sliding surface, and therefore only sufficient viscosity is needed in the cylinder oil to form a seal.

Determination of Proper Lubrication

We have given above some of the factors which determine the selection of the proper oil to use in a steam cylinder operating under certain conditions. These recommendations have been general, as there are so many factors entering into the situation that a definite recommendation is difficult. Of course, the real test of a cylinder oil is the condition of the rubbing surfaces after it has been used. In making an examination of a cylinder running on a certain oil, too hasty a conclusion as to its value should not be reached. It takes time to form a film surface on a cylinder wall, and if possible several weeks should elapse before the action of the oil is finally judged. A perfectly lubricated cylinder should be highly polished and have a glaze over its surface. It



SEPARATORS MUST BE USED IF CONDENSATE IS TO BE PUMPED BACK TO BOILER

should have no rough or dull spots, and there should be no sign of rust if examined immediately after stopping the engine. The color should vary from a bright iron-white to a light brown or steel blue.

If the cylinder head is removed immediately after stopping the engine, there should be a film of oil all over the surface sufficiently thick to saturate three or four thicknesses of cigarette papers. Even when the engine has stood for several hours, there should be a film upon the cylinder walls, though not necessarily as thick as if examined immediately after stopping the engine. The stain on the paper should be brown. If it is black or has black particles or streaks, the cylinder or rings are probably wearing or the oil is carbonizing. If there are pools of oil lying in the bottom of the cylinder or in the counterbore, too much oil is being fed and the quantity should be reduced. If the cylinder walls are dry in spots or show signs of wear, either too little oil is being fed or the wrong kind of oil is being used. Lack of lubrication will sometimes be shown when the engine is running, by sticky valves or groaning sounds from the cylinder. With Corliss valve systems, the slowness in action of the dashpot will give an indication as to the state of lubrication.

Economy of lubrication can be checked up by examining the exhaust steam or piston rod leakage. If the condensed steam shows considerable quantities of liquid oil, either too much oil is being fed or it is not properly atomized. If it shows minute drops of oil and is milky in color, it is probable that atomization is complete and the feed is correct. If the piston rod shows a film of oil on it and there is no oil fed directly to the piston rod, it can be taken as an indication that the atomization is satisfactory, or at least that the surfaces are receiving sufficient oil.

Summary

In this article, we have discussed the problem of steam cylinder lubrication, outlining the conditions that must be met and giving in a general way how they can be met and how the engineer can ascertain that he is getting good lubrication. The conditions which must be met are so variable and may appear in so many different combinations that it is practically impossible to make recommendations to cover each individual case. There are, however, a few general facts which stand out:

1. The lubricant must be of such quality that it will meet equally well the temperature conditions which may differ considerably in the various parts of the system.

2. The lubricant must be applied in an efficient manner. While the direct system is still used in some places, the atomization system is generally preferable to the direct method as the steam, which acts as a carrier for the lubricant, reaches practically all points that it is necessary to lubricate.

3. In the atomization system, the lubricant should be applied sufficiently far back in the main steam line as to secure complete atomization.

4. The ease of atomization depends upon the temperature, velocity and saturation of the steam, as well as on the design of the lubricator and the character and quality of the oil. High temperatures and high velocities give better atomization than low temperatures and velocities. Low viscosity oils atomize more quickly than high viscosity oils. Filtered oils atomize more quickly than unfiltered oils. Saturated steam is a better carrier than superheated steam. If it is necessary to introduce the oil close to the cylinder, one of low viscosity is generally necessary.

5. Steam refined and filtered oils are not necessarily better than fire stocks. Unfiltered and heavy bodied oils adhere to the cylinder walls better than filtered and light bodied oils. It is generally the practice to use the heaviest bodied oil that will atomize completely.

6. Mechanical lubricators as a general rule give better service than hydrostatic lubricators.

7. With high steam temperatures, an oil of higher viscosity can be used than with low steam temperatures. High-speed and vertical engines as a general rule require an oil of less viscosity than horizontal and low-speed engines. Oils can be classified according to viscosity as follows:

Light bodied, 95-115″ Saybolt Universal Viscosity at 210° F.

Medium bodied, 115-135″ Saybolt Universal Viscosity at 210° F.

Heavy bodied, 135-160″ Saybolt Universal Viscosity at 210° F.

8. High temperatures cause greater evaporation losses than low temperatures.

9. High temperatures and excessive quantities of oil may cause carbonization. The more refined oils carbonize less than the fire stocks.

10. Compounded oils are more efficient than straight mineral oils, and should be used in all cases where wet steam conditions exist, unless it is necessary to recover the condensed steam. Even in the latter case, compounded oils should be used if it is practical to separate the oil from the water. Compounded oils are separated from water with difficulty.

11. Priming boilers destroy the efficiency even of compounded oils. If this condition exists, it is necessary to use an oil with high adhesive qualities, compounded to take care of conditions.

12. Boiler impurities separate from oils of low viscosity more satisfactorily than from oils of high viscosity. Compounded oils cause less trouble with boiler impurities than straight mineral oils.

In studying any particular case, it is generally found that there must be a compromise of qualities in order to get a lubricant that will be of the most practical value under the actual conditions. Unless an analogy can be made with some other engine of a similar type, it is advisable when stipulating the character of a cylinder oil for a steam engine that the advice of a steam engineer experienced in lubrication should be requested. A careful inspection of the cylinder walls and other lubricated surfaces will reveal to this engineer whether or not the engine is receiving correct lubrication, and his experience will enable him to correct any defective lubrication if it exists.

Types of Ice Dumps

TYPES of ice dumps used in dumping the ice from the can are many, and depend largely on the date of installation and size of plant or capacity of the pull. In many small plants the sprinkler dump is used on account of elimination of cost and space required by a dip thawing tank. While the sprinkling of water on the sides of the can is not as efficient in heating all the surface as in complete submergence, still it will thaw, especially when augmented by the use of a hand-hose, and on account of the time required this type has its place generally only in the small capacity plant.

From a standpoint of design, the dump generally used in the large can plants is an adaptation in principle of the tipping table of the plate plant. It must be large enough to accommodate the number of cans pulled, must be strong and sturdy to withstand repeated shock, and be positive in action and easy to operate.

There are some dumps in which each can is mounted on a common shaft and dumped individually by hand. There are others where the loaded dump is tipped over by hand as an integral unit, but this type is seldom used on account of the fact that greater accuracy is required in determining the correct location for the center of gravity in relation to the center of rotation, inasmuch as the rotating load is frequently over 2 T. The modern plant, especially the complete electric plant, has a slow speed electric-driven dump hoist of 1½ hp. or so, which handles the heavy load mechanically, positively and quickly, and is probably the most modern development in this class of equipment.

JOHN BURROUGHS said he got heat out of his wood twice, once when he chopped it and again when he burned it.

Desulphurizing Effect of Air on Coke

AS THE RESULT of an investigation of the desulphurization of coke by air, conducted by the Department of the Interior at the Pittsburgh experiment station of the Bureau of Mines, the following conclusions are drawn:

1. At temperatures near 500 deg. C. it is possible to oxidize the larger part of the ferrous sulphide in coke to iron oxide and free sulphur, without causing any appreciable oxidation of the coke itself.

2. The free sulphur produced is retained in the coke in an absorbed form. It has been found impossible to remove this from the coke completely, and even part removal has been very difficult.

3. The investigation has indicated that the industrial desulphurization of coke by air treatment is not practical as far as the methods which have been tested would apply. The chief difficulty in the application of the process lies in the tenacity with which the free sulphur is retained in the coke. If a method could be found for the complete removal of this free sulphur, metallurgical coke could undoubtedly be improved by the air treatment, since the solid-solution form of sulphur, and the remaining ferrous sulphide enclosed in the coke-walls, do not have the contaminating effect on the iron in the upper planes of the blast-furnace that would have the ferrous sulphide which is capable of oxidation by this process.

Wasted Letters

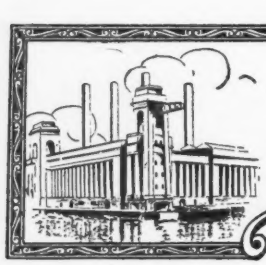
"WOULD you repeatedly send a salesman to a town that does not exist, or to see a man whose permanent address is the cemetery, or to see a firm at an address from which they moved years ago?"

This question is asked by Postmaster Arthur C. Lueder in a message which he is sending out to business men in Chicago. The reason for it is that tons of expensive circular mail are sent to the Chicago Post Office every year, at a cost of hundreds of thousands of dollars, which has to be destroyed because it is addressed to towns that do not exist, or to men long since dead, or to discontinued addresses. And letters and circular matter are sent out over and over again by the same firms to these "dead" addresses because their mailing lists are not corrected.

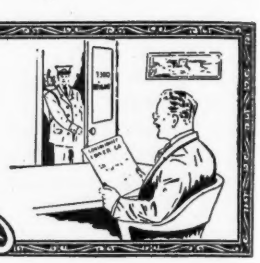
Third class mail is not returned to the sender unless "Return Postage Guaranteed" is printed on the envelope beneath the return address. So the sender believes that his advertising is reaching possible customers, whereas much of it may be going to swell the income of the junk man.

Mr. Lueder states that a good mailing list depreciates about 42 per cent a year, so that, unless kept corrected, a list which may be gilt edged when made up will be 84 per cent wasted effort and expense at the end of two years. To weed out "dead" matter, the "Return Postage Guaranteed" and the return address on the envelope will tell what mail cannot be delivered, so the names can be taken off the list.

In this way the list is sure of being "alive" and the slight expense of return postage will be repaid many times by saving the cost of sending out undeliverable mail.

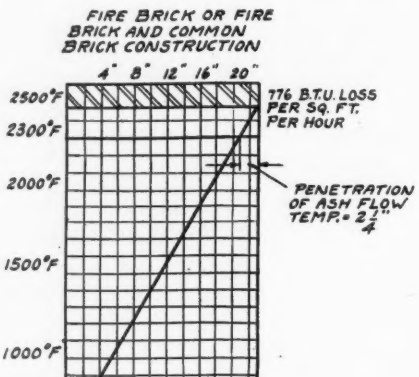


LETTERS DIRECT FROM THE PLANT



Insulation of Furnace Walls

In the June 15 issue of Power Plant Engineering, C. A. Frankenhoff treats us to a rather speculative account of the economy possible with the use of "insulating" brick in boiler settings. Examples are used, not from actual installations, but from calculations based, apparently, on the rate of conductivity through the brickwork. Much has been written on this subject but so far as I know there have been no comparative tests of settings with and without the insulating brick.



TEMPERATURE GRADIENT THROUGH AN INSULATED FURNACE WALL

Articles on the subject of insulating brick are usually accompanied by charts on which temperatures are plotted against wall thickness. The curve of temperature drop is always a straight line beginning, not with the actual temperature of the inside face of the wall, but with furnace temperature, and ending with the temperature of the outside face of the wall. By referring to Fig. 1 of Mr. Frankenhoff's article, we find the temperature of the inside face of the wall is 2500 deg. and the outside face 500 deg. The inside temperature is probably taken with a radiation pyrometer if it is not estimated from the color of the fuel bed; and the outside temperature is very likely determined with a thermo-couple imbedded in the brickwork.

I think it is pretty well established that surfaces exposed to heat are at a much lower temperature than the source of the heat because of the effect of the film of air, or gas, that adheres to the surface. Consequently the inner wall surface of a furnace will not be at the same temperature as the fuel bed, or the combustion zone. The actual temperature could, of course, be determined with a thermo-couple.

Referring again to Fig. 1 of Mr. Frankenhoff's article, and following the temperature gradient down to its intersection with the line representing a distance of 17 in. from the inside face of the wall, we find a temperature of 1050 deg. F. Are we to believe that at 17 in. from the inside face of a brick wall enclosing a space that is at a temperature of 2500 deg., there exists a temperature a hundred degrees above red heat? Would a piece of iron imbedded at this point be red hot? I think not.

In the Portland Cement industry raw material is burned to a clinker in rotary kilns. The temperature in the clinkering zone is upward of 3000 deg. F. These kilns are lined with 9-in. blocks of firebrick and in many cases 6-in. blocks are used. Here we have a furnace temperature of 3000 deg. enclosed by 6 in. or 9 in. of firebrick and this covered with 9/16-in. steel plate. What is the temperature of the steel plate outside the high-temperature zone of the rotary kiln? I do not know. I do know, however, that it is nowhere near red-heat because I have often touched it with my fingers with no unpleasant results.

I believe there is something radically wrong with the methods used by makers of insulating brick in computing the heat loss through brick walls; or perhaps some unwarranted assumptions are made which lead to erroneous conclusions.

Phenomena of heat-transfer from furnace to, and through, the brick wall, as I visualize them, are as follows: The heat from the fuel bed is transmitted by radiation and convection to the face of the wall. The greater part of this heat is radiant heat, a large part of which is reflected to the heating surface of the boiler. Heat being a form of energy, and temperature being a measure of the velocity of vibration of the molecules of the brick, there is probably (in heating by conduction) a condition analogous to friction effect, or inertia effect, which slows down the velocity of the molecules (and, which is the same thing, lowers the temperature) by an amount that would be expressed inversely as some power of the temperature. This point could, of course, be settled by placing a number of thermo-couples at varying distances in the wall.

That some such thing as the foregoing must be true seems to be borne out by the case of the cement kilns cited. The following is another practical example:

Some years ago when dismantling two batteries of 400-hp. boilers, I found a 12-in. I-beam column in the battery wall, which column was one of the supports of the boilers. As originally installed, the column was partly in the battery wall and partly in the front wall of the setting. Later, when stokers were installed with an extension furnace, or "Dutch oven," the position of the column was mid-length of the furnace. Here was a

steel column imbedded in a 22½-in. firebrick wall, with the edges of the flanges 8¾ in. from the surfaces of the wall. These furnaces had alternately burned coal and oil as dictated by the prices of these fuels. At times the temperature of these furnaces had, no doubt, exceeded 2500 deg. According to the temperature gradient accompanying Mr. Frankenhoff's article, the temperature in the middle of a 22½-in. wall would be about 1500 deg. for a condition of furnace temperature on one side and room temperature on the other. Now, if the temperature gradient is as illustrated, then the temperature of the steel column should have been at least 1500 deg. A steel column at 1500 deg. temperature, several hundred degrees above that at which the elastic limit is reached, would certainly be of no value as a structural member, yet this column carried a load of many tons over a period of several years and, when examined, bore no traces of ill effect from heat.

In days gone by, some ridiculous errors have been made in figuring heat transmission through steam radiators, condenser coils, and materials of construction, because conductivity alone was considered, and the surface resistance (which is sometimes the largest part of the temperature drop) was ignored, or was unknown.

So far as insulating value is concerned, good results can be obtained with common red brick at less cost because 3000 or 4000 common brick can be laid in the wall at the cost of 1000 of the insulating brick. Furthermore, the greater thickness and density of the common brick wall assists in reducing loss from air infiltration—the insulating brick being extremely porous. In fact, a test may disclose that the loss of efficiency from air infiltration through a wall built of insulating brick is greater than the loss by heat emission from a wall of common brick of the same thickness. Also, the infiltration of air will have the effect of cooling the brickwork, which effect might erroneously be credited to the insulating brick as "insulating" value. Of course, air infiltration would not be a consideration where the boiler setting is encased in steel plate.

There are a number of small errors in Mr. Frankenhoff's calculations, but they have little significance. There is, however, great error in assuming that any boiler has 1040 sq. ft. of furnace wall at a temperature of 2500 deg. This assumption is the basis of the economy results arrived at by the calculation.

Long Beach, Calif. C. O. SANDSTROM.

Pressure Mania

I READ with unusual interest the editorial in the June issue of Power Plant Engineering under the heading "Pressure Mania."

While it might be dangerous business so far as my reputation is concerned to make any predictions, I am willing to put myself down in black and white as believing that engineers will eventually settle down on about 600 lb. as the economical maximum pressure. I agree with the editor that we may be overshooting the mark and that we will come down to a more common sense pressure. Germany demonstrated, for instance, that it is possible to shoot some 70 mi. with an enormous special cannon; but so far as I know, no nation is building such guns at the present time because they are impracticable. In the same way, my belief is that the higher we go above 600 lb. the more impracticable will the boiler be.

My reason for this (shall we call it pessimism?) is the same old reason that confronted James Watt—leaks. Watt's principal trouble was the prevention of leaks. One of the principal troubles today is the stopping of leaks; and as we advance the pressure, the greater is the tendency to leak. We have numerous advantages today over James Watt for leak prevention, the principal one being welding. However, will it be economical to weld all of the tubes into the boiler, all of the handholes and manholes, etc., so as to prevent all possibility of leakage? I recently had an experience with a manufacturer of refrigerating machinery using ammonia. It was found necessary to weld the boilers so as to prevent all leakage. There was no riveting or belting whatever; but when it became necessary to remove the coils inside of the boiler, the entire boiler had to be cut in two and the parts replaced and then welded together again, which was, of course, expensive. In spite of the boilers being entirely welded, leaks would occur anyway in the piping which contained ordinary ammonia joints. I fear that the same kind of trouble will be experienced with steam boilers and steam piping under extremely high pressure.

N. G. NEAR.

Use of Lead Wool for Packing

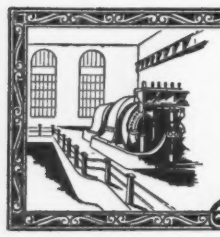
WHERE PISTON or valve rods have become scored and there is considerable trouble in obtaining a tight joint at the packing box, due to inferior packing and defective rods, a great improvement is secured by using the following method. Carefully twist some shredded lead into a thin roll of diameter equal to that of the regular packing and place a turn or two of it in the packing box, then add a turn or two of the regular packing on top of the lead, alternating until the box is filled. The gland nuts are then turned up tight to compress the lead and then slackened back. Often this scheme will give a satisfactory job with poor packing. If thin tea lead is carefully applied it will give as good service and results as the shredded lead, or lead wool as it is sometimes called. This material can usually be obtained from any dealer in plumbing supplies at a cost of 10 cents a pound. This method used in locations where the rods are in excellent condition and the packing of good quality will oftentimes prolong and even double the time a joint will remain tight. I have used the method for hot and cold water and steam with equally satisfactory results.

Toronto, Ont. JAMES E. NOBLE.

Mirror as a Reflector for the Water Column

ORDINARILY A boiler gage glass is not the easiest thing in the world to see; at least I have found it so. To eliminate, as far as possible, any error in reading this instrument, I have for a number of years used a reflector made from a strip of common-looking glass. I cut a clear piece of mirror about 3¾ in. wide and long enough to slip in back of the gage glass fittings. I then cut a piece of tin large enough to bend up over the edges as a backing. This assembly I then fixed to the gage fittings immediately behind the water column. With this arrangement I find there is a marked increase in visibility.

R. C. HENDEE.

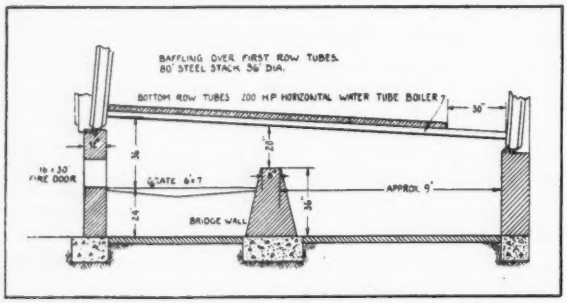


PROBLEMS IN OPERATING POWER EQUIPMENT

Change in Furnace Setting to Prevent Smoke

I WOULD like to have the opinions of my fellow readers of Power Plant Engineering as to what changes would be recommended on the boiler setting shown in the accompanying sketch to reduce smoke formation.

Where wood is used as fuel in our case, and we have more than plenty, would it be of any advantage to use an inclined hand stoker? We could not realize much



FURNACE SETTING FOR A HORIZONTAL WATER-TUBE BOILER THAT PRODUCES SMOKE

from the coking feature of a hand stoker because much of our fuel is fed into the furnace in bundles made up of sticks 4 ft. long. We thought the greatest good would result in assuring a better grate covering, due to the inclination of the grate—it would really be a help to the fireman.

We should like to know if it is possible to get smokeless combustion without resorting to the use of some auxiliary device which feeds additional air into the furnace.

Our present boiler room will not permit of our extending the furnace toward the front, but by making extensive changes in piping and side walls we could raise the boiler setting.

We must install a new front, grates, and reline our walls in the furnace, and would appreciate hearing from readers before doing this, so that we could incorporate in the changes anything tending to cut down smoke. F. G. F.

Scale in Feed Water Line

WE HAVE about 60 ft. of feed pipe leading from a closed heater to 150-hp. return tubular boiler, which fills up with sediment or soft scale.

Our feed water is taken from a pond which is fed by a large brook. The water is soft and apparently clear, but about every eight months we have to remove this feed line and clean it out.

We are desirous to know what can be done to prevent this mud from getting into the feed line. As it is a small plant, we do not feel like investing a large amount of money for this purpose.

We are thinking of installing a filter and grease extractor, but it is not recommended that we put the filter between the heater and the boiler. G. T.

Would an Air Lift Pump Be Advisable?

WE CONTEMPLATE installing an air lift pump in a well at our plant and I would like to have an opinion from the readers of Power Plant Engineering on the design suggested here. The well is 310 ft. deep and the water level is 18 ft. below the surface. The casing is 12 in. in diameter and as at present designed the air and discharge lines are 100 ft. long and ¾ in. and 4 in. diameter, respectively. The air pump is 4 by 4½ in. and delivers under a pressure of 50 lb. gage. F. W. L.

Will Two Feed Water Systems Be Necessary?

WE ARE putting up a vertical water tube boiler which is to carry 150 lb. pressure. A reducing valve is to be placed in the steam lead to reduce the pressure to 120 lb. to suit the other boilers in the plant. Will it be necessary to provide a separate feed pump for this boiler or can regulators be installed to feed all boilers from one feed water system? We have eleven tubular boilers which are fed from a 6 in. feed water header through 1½ in. leads. Can a pressure of about 175 lb. be carried on this header to feed all boilers? When the feed valves on the 120-lb. boilers are open, will it rob the 150-lb. unit of its feed water? A. C.

Oil Burning Installation; Design of Air Lift Equipment

I WAS much interested in the inquiry from J. O. S. in the June 15 issue of Power Plant Engineering as to the suitability of the oil-burning furnace which he described. I do not see how he can get good results from such a design. The burners are too close to the boiler and two burners under a 72-in. by 18-ft. boiler are too many, as there is insufficient combustion space.

The proper layout for a 72-in. by 18-ft. horizontal return tubular boiler is to have an open space the length and width of the boiler, the floor of the firebox to be 48 in. from shell of boiler, the burner to be 42 in. from boiler. Only one burner should be used, air openings in the ash pit should be large enough so as to permit of closing or opening to admit air in different volumes as needed.

I have been using fuel oil under 14 horizontal return tubular boilers 72 in. by 18 ft. and have only 1 burner to each boiler and I can get any size of fire I want by simply opening or closing the steam or oil valves.

I would like to ask J. O. S. what per cent CO_2 he gets with his layout, also what draft he uses and how much oil he burns under each boiler. Let us have more about burning oil. S. E. CUNNINGHAM.

New Bedford, Mass.

ON PAGE 648, of the June 15 issue, J. O. S. wishes the opinion of readers on an oil-burning installation which he describes. The only erroneous arrangement of the installation is the method of air introduction. The air for combustion is carried too far back into the furnace. It does not admit the air to the atomized gases properly. The furnace, as shown, will give trouble, due to the slagging over of the air ports; and as these ports close, the capacity of the boiler will be diminished, due to the effect of insufficient air. All of the air for combustion should be admitted directly under the burner tip through an opening approximately 12 by 12 in. The

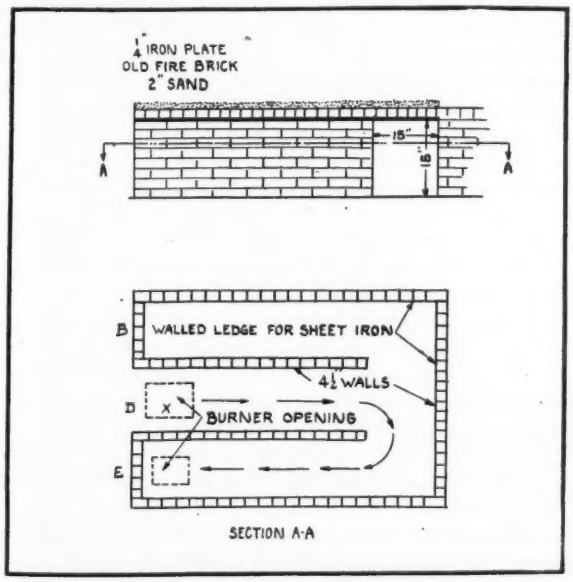


FIG. 1. DESIGN OF OIL-BURNING FURNACE TO GIVE PROPER AIR DISTRIBUTION

present arrangement does not allow the immediate production of CO_2 as should be the case.

I would suggest that J. O. S. rearrange his air introduction as shown in the accompanying sketch.

From the description of the boiler, I should judge that it has a rating of 150 hp. If this is correct, he will not want to run it at more than 150 per cent rating. In this case, one burner will be sufficient. I have had charge of boilers of this type and have been able to develop easily 225 hp. with one burner. All that would be necessary to change the air introduction from a two-burner to a one-burner would be to close the opening and open the designated places B and E. Of course it would be necessary to close the two-burner openings and make one opening at X.

J. O. S. will find this type of setting well adapted to the type of boiler he has and if he will be careful to bring all of the air directly under the burner tips he will find his furnace will function excellently.

An article on the same page requests the opinion of readers concerning the discharge head of an air-lift arrangement.

My honest opinion of the three arrangements illustrated is that none of the three is suited for the economical delivery of water by this method; however, if it is necessary for him to use one of the exhaust heads, No. 3 is best suited for his needs.

In my opinion, the three exhaust heads are not correct for the following reasons. In order to deliver water at a low cost with air-lift equipment, it is absolutely

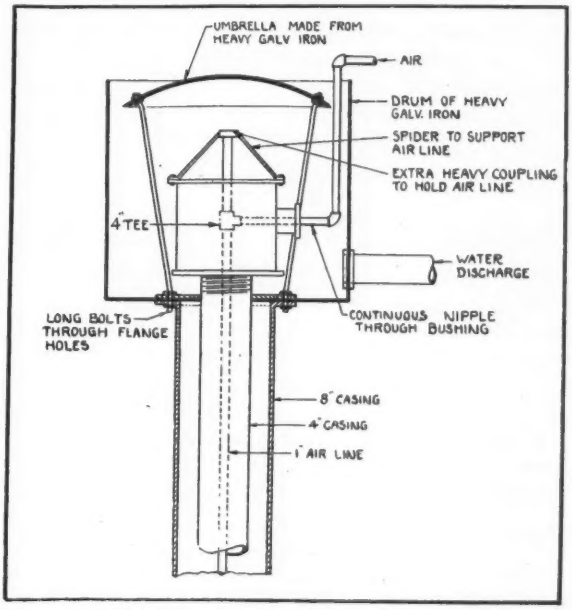


FIG. 2. EXHAUST HEAD FOR AIR LIFT WELL

essential that there be no back pressure on the well. With exhaust heads as shown, the abrupt discharges have a buffeting effect on the water and air being discharged, thereby causing a back pressure in the well. The slippage in the well is what impairs the efficiency and if a well has considerable back pressure, that slippage is augmented to a great extent; therefore it is best to have exhaust heads that exhaust the air and water outside of the well casing. The exhaust must be free from abrupt turns.

The choke effect in diagram 2, of this article, is erroneous and should be done away with if he is to secure a reasonable efficiency from his foot-pieces. The choke effect can and does cause sufficient back pressure on a well to waste 85 per cent of the energy delivered at the foot-piece.

Recent experiments show that an average efficiency of 54 per cent can be obtained from properly designed foot-pieces and exhaust heads. I would suggest that C. D. R. fashion an exhaust head on his well as shown in Fig. 2. This arrangement allows the free exhausting of air and water outside of the casing, thereby causing practically no back pressure on the wall. It is possible to gain maximum efficiency from this head provided the foot-piece is placed at the theoretically correct point.

Houston, Texas. FRANK A. ROTHWELL.

POWER PLANT ENGINEERING

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Air Supply is an Important Station Problem

Air is one of the factors in power plant operation that is free to all. There is plenty of it—in fact, too much at times. Possibly the fact that air is free of cost has been the reason that comparatively little attention has been given its use in power plant work.

As a matter of fact, air plays an important part in the expense of operation, considered not alone from the combustion side of the question but from the standpoint of the plant layout and resulting overhead cost.

Under the most favorable conditions approximately 12 lb. of air are required per pound of coal consumed which means that a plant using 50 T. of coal per hour would require 600 T. of air in the same period of over 250,000 cu. ft. per minute. Assuming that in such a plant the coal consumption is 2 lb. per kw.-hr., this would mean a station rating of 50,000 kw. As the generator cooling calls for from 3 to 5 cu. ft. per min. per kilowatt of capacity, the air supply for this purpose would be roughly about 200,000 cu. ft. per min.

As the combustion air passes to the atmosphere, it is necessary to replace this air, some 250,000 cu. ft. of it, each and every minute. Where is this air to come from? If it is drawn into the boiler room from the outside, then in the winter time the temperature of this section of the plant will be rather frigid unless a lot of money is spent for heating. If drawn through from the turbine room, the cooling air from the generator is only partly sufficient for the purpose. The balance must come from the outside. If this cold air is drawn into the turbine room a heavy fog may result either locally or throughout the entire room.

Closed systems of generator ventilation have added to the complexities of the problem. In such a case all of the combustion air must be drawn in at the prevailing outside temperatures. Directing this air so that it will not cause drafts or condensation and so that the station will not be oppressively warm in the summer is a problem. The inevitable use of air preheaters will add another factor.

This problem is no less important in the small station where frequently no provision is made at all for a definite scheme of air flow. In fact, some office building plants, located in sub-basements, have been noted where this point has been ignored to the extent that it affected combustion.

Air is just as important as coal or water and the method of handling it should be studied with as much care as if it were to be entered as a part of the plant expense at so much per thousand cubic feet.

Location of Central Stations

In considering the most economical power supply the question of locating large steam power plants at the coal mines and transmitting power to the cities electrically has received much attention of late and has been discussed from many angles. The successful development of long high voltage transmission lines for transmitting hydroelectric energy to the cities naturally suggests that coal be burned at the mine to develop electric power for transmission to the cities, thus saving the expense and uncertainties of rail shipment.

While upon first thought the idea sounds logical, there are a number of obstacles in the way of its successful application, foremost among which is the prevailing absence of sufficient condensing water for a large steam plant at the mine sites. Rail freight rates, it is true, have increased enormously during the past three years, but as W. L. Abbott of the Commonwealth Edison Co. pointed out recently in a talk before the American Society of Civil Engineers, it is doubtful whether even under the most favorable conditions in the Middle West a power plant would be warranted in maintaining a power plant at the mine, a stand by plant in the city and a transmission line between.

Conditions, moreover, are seldom "most favorable" and a quantity of flowing water necessary for a condensing plant upwards of 50,000 kw. is seldom found at the mines. Even if sufficient water is available at what may be considered short distances from the mines, say from three to fifteen miles, coal will have to be shipped by rail over these distances. And it is just this point of handling the coal that makes shipment by rail expensive. In many cases, the basic charge for handling the coal is by far the greater cost of the total freight charge and for this reason the freight charge will vary little whether the coal is shipped ten miles or a hundred.

As a matter of fact, however, the larger public utilities have gradually been building their large steam generating stations supplying energy to the cities closer and closer to the coal mines; not, perhaps, in all cases with respect to actual distance, but with respect to the ease of bringing in coal trains. Ten and fifteen years ago most of the large electric generating stations were located in the heart of the cities they served. As time went on, however, the newer plants were built farther away from the centers of consumption until now many of the larger plants are on the extreme outskirts or beyond the limits of the city proper. This is as it should be. Not only will it tend to lower the cost of coal shipments because of the decreased terminal charges, but it will reduce to some extent the smoke nuisance of our cities and preserve the value of the residential communities.

Co-operation Needed Between Designer and Operator

It is the recognized duty of every power plant design engineer to select and arrange equipment such that economy of operation may be obtained. It is his further duty, but one which unfortunately is not always recognized, to follow up his work, to know that it was installed as specified, and that an effort at least is being made to operate it as he had planned.

If results are not as he had anticipated, it is up to him to find out why. The practical operation of a power plant will emphasize many details of construction which did not appear of great importance in the drafting room, or upon which the designer erred in passing judgment.

It is not to be expected that the solution of these problems should be left wholly up to the operating engineer. It is true that they are operating problems; however, the one best way to rectify them and to avoid future mistakes is through the co-operation of designer and operator.

We have in mind waste heat installations where the safety valves blow for hours at a time. The questions immediately arise whether waste gas bypasses and damper control have been provided, and if so, why the operator is not taking advantage of them. Surely the operator knows that safety valve repairs will be high and that evaporating more water than is required will mean higher cost of operation due to blowdown loss, additional feed water treatment and added labor for cleaning or scaling the boilers and heaters. Many drip connections will be found that are discharging to the sewer when the closing of one valve and the opening of another would return that hot water to the feed water system.

These and many similar conditions can be rectified by co-operation and personal interest of both the designer and the operator. As these principles are followed out more closely, we shall find less and less of what may justly be called bonehead engineering as applied both to design and operation.

Report of the U. S. Coal Commission on Anthracite

In a report on anthracite to the President and Congress, the U. S. Coal Commission has in substance taken the stand that coal is as much a public necessity as gas, street railway service or any other service or commodity that has been brought under public regulation. Further, that while government ownership is not to be desired, it is not right that a limited natural monopoly such as anthracite should continue to be treated as if it were not affected by public interest. The recommendation is accordingly submitted that the anthracite coal mining industry be made subject to government regulation. This will no doubt make its appeal as being equitable to all concerned.

In all, twenty-one recommendations are made, among which are the four that follow: reduction of the number of commercial sizes from seven to four, inspection of quality, larger use of substitute and supplementary fuels and better combustion practice. These specific recommendations point out clearly the path to be followed by the engineering profession.

Complaints of poor quality of coal are a common feature on the recurring shortages of anthracite. The complaint is not confined to isolated carloads of "fireproof" coal shipped by "snowbird" operators. There is a widespread feeling that quality deteriorates during periods of scarcity and that much dirt, slate and bone is passed on to the consumer. It is this feeling that has inspired bills providing for government inspection introduced both in Congress and in the legislatures of several states.

We must conserve all grades of anthracite by sustaining improved combustion practice; improvements must be made in the manufacture of briquets; powdered anthracite must be applied more generally for power generation; and studies should be begun at once as to the economy and practicability of substituting some supplementary fuel for anthracite.

These are problems for which a solution must be sought today. They should not be delayed until the general anthracite situation becomes still more critical.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Submerged Orifice Principle Used in Proportioning Flow

WHILE the weir method of proportioning the water flowing to the control tank and that flowing to the sedimentation tank in a water-softening system has given satisfactory results, the Graver Corporation, of Chicago, has recently applied the submerged orifice principle to the feed control, due to the increased accuracy obtained.

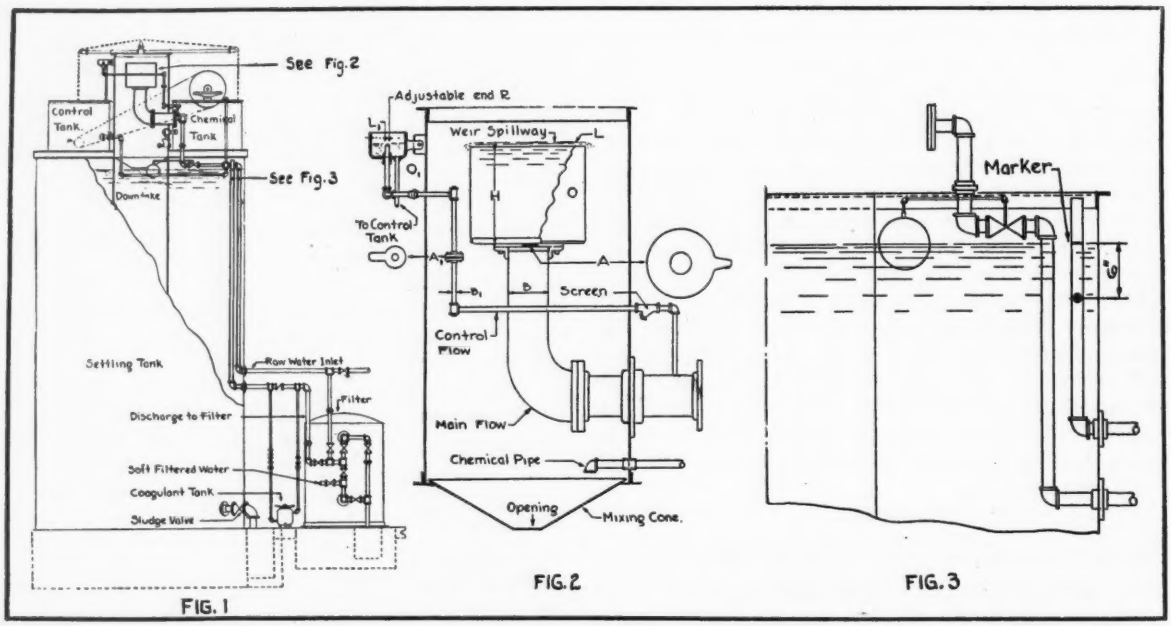
This general method of measuring chemical accurately in proportion to the amount of water flowing into the softener is called the "divided flow" method. The incoming raw water passes through the two orifices A and A_1, each measuring a part of the supply. These orifices have a fixed relation to each other, which gives a proportional flow through each.

Water passing through A rises in the chamber O, is discharged over spillway L into the downtake of the settling tank. That portion flowing through A_1 discharges over spillway L_1 in chamber O_1 and goes through a pipe to the control tank. The orifice A_1 is so calibrated that when operating the softener at the normal rate the control tank will be filled in twelve hours.

In this proportioning method the accuracy depends entirely on the submerged orifices used. Both orifices always discharge under water in a solid (full) stream. There is no chemical passing through either orifice. This is important as hydrated lime—the usual water-softening chemical—will form a deposit on any orifice which would destroy the accurate calibration and cause inaccurate proportioning.

For regulating purposes as practiced in water softening, the flow through a small submerged orifice is more accurate than that through a similar opening discharging free or directly into the air or through a small weir, which can be considered a special case of an orifice in which the water surface does not touch the upper part of the orifice. In each case the actual discharge is modified or decreased by a co-efficient determined experimentally or based on previously accepted and recognized hydraulic data.

Orifices A and A_1 consist of a thin brass plate 1/16 in. thick, accurately drilled and smoothly finished to a specified diameter. The plate is inserted between flanges and provided with handle for each in removing. The cross section of small orifice A_1 is calibrated for a fixed head



FIGS. 1 TO 3. ACCURACY IN THE CHEMICAL FEEDS IS AN IMPORTANT POINT IN WATER SOFTENING SYSTEMS

In Fig. 1 is shown a diagrammatic layout of the entire water treatment system while Fig. 2 shows an enlarged detail of the submerged orifice method of measuring the chemical accuracy in proportion to the amount of water flowing into the softener. Figure 3 is a detail of the rate control orifice. A head of 6 in. is maintained on the orifice as shown.

to fill the control tank in 12 hr. Operating under this head same head the diameter of orifice A is determined to discharge the rated capacity of softener. To care for a wide range in operating conditions, say 10 to 50 per cent of actual capacity, other sizes of orifice plates can be furnished.

These openings are independent of the area of pipe on the softener, as the channels of approach B and B, to each orifice are large. The flow is likewise proportional to the pressure in raw water line as the counter pressure or submergence of orifices is the same. This does not imply that orifices A and A, must lie in the same plane.

Counter pressure is determined by the head flowing over the large spillway L which acts as a circular weir. The length or circumference of the weir is so large that the head above the crest is fairly small. This same head or level can be transferred to orifice A, by the adjustable ferrule or pipe nipple R. This is set when the softener is first placed in operation. The length of L, and L are proportional to the discharge through orifice A, and A. A slight unevenness in the flow over the spillways does not affect the accuracy of the proportioning as the discharge through an orifice depends on the average static head H. This is not the case in the flow through weirs. Any change in flow, therefore, affects both orifices similarly.

A further refinement is introduced by the rate control orifice Fig. 3. This is an opening cut in the softener outlet pipe in the settling tank. It acts as an orifice, discharging the rated capacity of the softener under a head of 6 in. This head is controlled by the float valve on the raw water inlet line. When setting a softener in operation, the water level is fixed by a marker on this pipe. A slight movement above this mark will close the float valve until the demand slackens. If the water level falls below this mark, it means the orifice will discharge less than capacity, hence the float valve opens until equilibrium is restored. The pipe is extended to the top of settling tank so that the orifice is under atmospheric pressure. If the outlet pipe were connected to a pump, the water level could only be drawn down to the bottom of the orifice. The rate of flow through the submerged orifices is therefore constant and in fixed proportion for each size apparatus.

An Improved Transformer Thermal Indicator

TO INDICATE the temperature of the hot oil in distribution transformers a new device, known as the Transformer Thermal Indicator, has been placed on the market by the Westinghouse Electric & Manufacturing Co. The new indicator, which may also be adapted for use on any oil-insulated electrical apparatus, was developed to meet a demand on the part of central stations for a device that could be easily installed and would indicate accurately the actual and maximum temperature of the oil. All other devices developed heretofore have been of the semaphore or flag type.

This indicator is actuated by an alcohol thermometer with the bulb at the end of a flexible tube which can be placed at any desired point in the oil of the transformer. Pressure from the bulb is transmitted by means of a capillary tube to an operating mechanism constructed on the principle of the Bourdon gage. The indicating dial of the instrument has large figures and is mounted at an angle of 30 deg. from the horizontal on the side of the transformer tank, where it can be easily read from the ground. Two pointers are used, one red to indicate the maximum temperature of the oil and the other black to indicate the actual temperature of the oil at the time of reading. The red pointer makes it possible to detect either an underloaded or an overloaded transformer. The device has the advantages of accuracy and

THERMAL INDICATOR COMPLETE WITH FLEXIBLE TUBE AND BULB

simplicity and is dust-proof, water-proof, bug-proof and rust-proof.

If desired the indicator can be mounted on the distribution transformer tank with the same fitting as the flag type transformer load indicator or in the thermometer or filter press connections of a power transformer. All of these fittings are below the oil level; but, if it is preferred to mount the instrument above the oil level, a hole can be drilled in the transformer tank, preferably at the side and directly over the oil ducts, so that the bulb and capillary tube will pass between the low voltage leads and the side of the transformer tank.

Power Plant of Los Angeles Dealt Blow

RECENTLY the United States Supreme Court declined to review the right of the city of Los Angeles to condemn the property of the Southern Sierra Power Co. on Owens River, near Long Valley reservoir, for use in increasing water and power resources.

This decision strikes a probably fatal blow, as far as the courts are concerned, at the efforts of the Los Angeles Municipal Bureau of Power and Light to secure hydroelectric power at the expense of the outside communities and follows closely upon a similar defeat of the Power Bureau at the hands of the Legislature when the Lyon bill was killed in committee.

For years the Power Bureau has been seeking to condemn a tract of land for hydroelectric power development purposes in the Owens River Valley belonging to the Southern Sierra Power Co. The United States Cir-

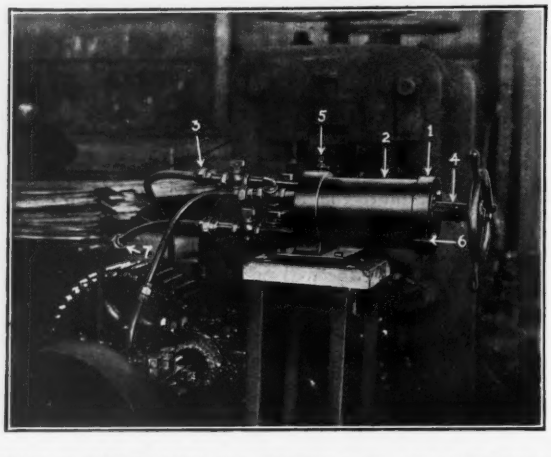
cuit Court of Appeals ruled that the Power Bureau's condemnation suit was illegal, and the decision of the Supreme Court upheld the action of the Circuit Court, the Supreme Court declining to review the Circuit Court's decision.

The only hope that the Power Bureau now has of getting this land away from the power company, which serves Riverside and other outside communities, is through legislation, and for this purpose the Power Bureau introduced into the Legislature this year the Lyon bill which would have given the Bureau the right the condemn any power land in any part of the state. This is the bill which was killed through the united opposition of the outside communities.

On the case which was ended by the Supreme Court decision, the Power Bureau has spent thousands of dollars of its revenue, including service of special attorneys, $50,000 which was deposited by the Bureau when the appeals were taken and expensive tunnels and other engineering work which was done near Long Valley in the Owens River district in the expectation that the Power Bureau would win its fight to condemn Southern Sierra Power company's land.

Bearings Lubricated from a Central Location

IN ORDER to assure the proper lubrication of bearings that are difficult of access due to small clearance between working parts, heat and other unfavorable



GREASE IS FORCED INTO ALL BEARINGS, OR ANY PARTICULAR ONE, BY A TURN OF THE WHEEL

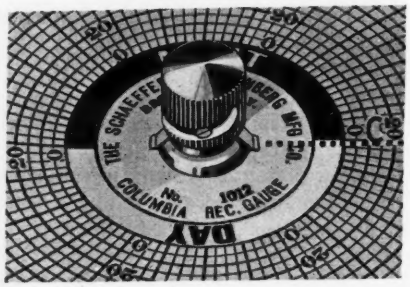
conditions, the Keystone Lubricating Co., of Philadelphia, has recently developed a system of applying grease under high pressure with pipe line distribution.

Referring to the illustration, it will be noted that the lubricator consists of a cylinder and a hand wheel which operates a piston. The magazine (1) is threaded and screws into cylinder (2). This magazine holds 8 lb. of grease and one complete turn of the wheel forces 4 oz. of grease through the leads (3). A gage (4) shows amount of grease in the magazine and the vent cock (5) allows air to pass into the vacuum formed in magazines when empty and thus allows it to be taken off by a spanner which fits into slots (6). The leads are ½-in. iron pipe and have stop cocks near the lubricator to control supply to the bearing, depending upon the distance grease is to be forced, any of which may be closed off completely. A union (7) near the bearing allows quick disconnection at any time.

In some instances, valves can be permanently adjusted to allow the grease to flow in uniform quantities to the bearings. This method, however, is not endorsed because of the possibility of some bearings being too generously supplied with grease; therefore it is recommended that at the time a general greasing is due, the operator turn off all valves excepting one. The plunger is then turned down until the particular bearing on which line the valve is open has been lubricated and then the valve is turned off and the next one opened, in order, and this procedure is continued until all bearings have been lubricated.

Button Need Not Be Removed When Changing Charts

BUTTONS for holding recording charts are somewhat like the proverbial collar button; they have a habit of disappearing at most inopportune moments. In order



METAL CLIPS GRIP THE CHART WHEN BUTTON IS GIVEN A QUARTER TURN

to eliminate this strain on the operator, recorders of the Schaeffer & Budenberg Mfg. Co. and the American Steam Gauge & Valve Co., Division of Brooklyn, N. Y., are now equipped with a special chart button.

As will be noted in the accompanying illustration, a simple quarter turn draws in two metal clips and permits the chart to be removed, another turn in the opposite direction pushes out the clips again and they grip the new chart firmly. This does away with the trouble of unscrewing and removing the button, and then replacing it every time a new chart is to be put on the instrument.

New Automatic Hydro Station Nearing Completion

WORK ON the 7500-hp. automatic hydroelectric station which the Adirondack Power & Light Co. is building on Sprite Creek near the outlet of Canada Lake has progressed to the point where it is expected that the plant will be in operation by October.

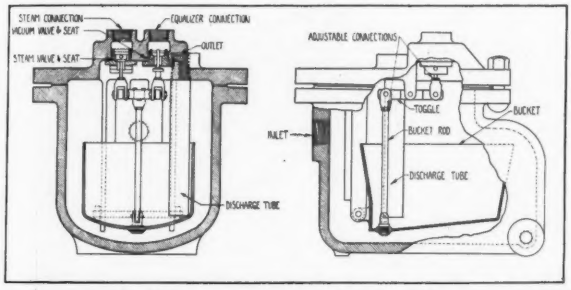
Sprite Creek station will connect with the transformer station at Ingram's Mills 7 mi. away, which is the center distributing point of the Adirondack Power and Light Corporation's system west of Amsterdam.

Not only will the Sprite Creek station be automatic, but it will be controlled by the operator at the station at Ingram's through an ingenious arrangement. When the operator wants power from the next station he simply closes the high tension switch at Ingram's. This actuates a small solenoid at Sprite Creek which opens the water wheel. The generating unit is brought up to speed or slightly over and the current synchronizes itself on the line. Production of power at Sprite Creek is stopped by opening the same distance switch, the automatic operation being reversed.

Vacuum Trap Brought Out for 1-In. Lines

STRONG, Carlisle & Hammond Co., of Cleveland, O., has added to its line of vacuum traps by bringing out one for 1-in. lines. No marked changes in the design are to be noted except for a rearrangement of the levers which makes a more compact unit.

Water enters the trap through the inlet check valve and collects in the body of the trap. As the water rises in the trap, it overflows into the bucket, causing the



OPERATION OF TRAP DEPENDS UPON THE RISE AND FALL OF CAST IRON BUCKETS

bucket to sink. This opens the steam valve and closes the vacuum valve. Pressure quickly builds up in the trap closing the inlet check and forces the water in the trap out through the outlet check valve. As the water in the bucket is removed the bucket becomes buoyant and rising, closes the steam valve and opens the vacuum valve. With the reversal of the valves, the pressure in the trap is equalized with that in the system to which the trap is connected and water again flows into the trap by gravity.

This type of trap is operated by steam pressure and will deliver water or condensation to any height above the trap, limited only by 1 lb. steam pressure equaling 2 ft. in height. They are used for such service as draining exhaust lines of condensing engines or other vacuum systems where it is necessary to place the traps in pits, or when it is desired to elevate the discharge.

Early Purchase of Coal Urged

AN OFFICIAL statement received from the American Railway Association points out that if coal consumers do not now purchase coal in anticipation of fall and winter requirements, they will experience difficulty in procuring it later in the season when railroads are taxed with a heavy movement of general traffic and particularly agricultural products. The Railway Associations point out that, while the carriers are in shape to handle and move all coal with reasonable promptness, provided the movement is distributed throughout the entire year, they are not provided with surplus equipment and facilities in sufficient quantity to offset in the fall months failure of consumers to buy coal during the summer months when sufficient transportation is available. They emphasize finally the importance of purchase of coal by consumers now for use during the fall and winter months.

Tachoscope Records Speed Until Reset for Next Reading

ONE interesting feature of a Swiss tachoscope which has recently been placed on the market in this country is the fact that the indicating pointer remains in position until the next reading is taken. This direct reading tachoscope gives readings of revolutions per min-

SPEEDS UP TO 30,000 R.P.M. ARE INDICATED BY THIS INSTRUMENT

ute or, using the disk-wheel supplied, feet per minute. The standard time unit adopted is 6 sec. and this unit is controlled by a precision watch movement fitted in the indicator. One and one-half sec. are allowed for starting and stopping the watch movement which also automatically switches the counting mechanism in and out at the start and finish of the 6 sec. reading unit.

For each reading one pressure on the button suffices, as the lever is designed not only to wind the watch but also to zero the counting mechanism from the previous readings. This does away with any necessity for resetting the counter after taking a test, the last reading remaining on the dial until the indicator has been placed in position on the machine under test and a new reading

is required. Then the finger is pressed on the knob and allowed to slide over it so that it can fly back to its full extent, thus resetting the counter and winding the watch.

Either a black or red disk is shown on the face of the counter dial, the color altering with the direction of rotation and corresponding to that of the set of graduations to be used, black for right hand, red for left hand rotation. One revolution of the large pointer = 1000 r.p.m. and one revolution of the small pointer indicates 10,000 r.p.m. (3333⅓′). The instrument is designed to stand up to 30,000 r.p.m. and all pivots and bearings are suitable for such high speed rates.

O. Zernickow, of New York City, is handling the sale of these instruments.

Ohio Public Service Co. Plant Nearing Completion

IT is expected that the 20,000-kw. plant which the Ohio Public Service Co. is building at Lorain, Ohio, will be ready for operation about October. From the accompanying construction photographs taken on April 7 and June 4, it will be noted that the erection work in the boiler room was making good progress on these dates.

THREE 1800-HP. BOILERS WILL SUPPLY STEAM AT 300 LB. PRESSURE TO A 20,000-KW. TURBO-GENERATOR

This plant is in reality an addition to the 8000-kw. station which now supplies the territory around Lorain and which is tied in with the Ohio system. It is expected, however, that as future 20,000-kw. units are added the old part of the plant will be held for reserve and eventually be dismantled.

Equipment in the new section will consist of one 20,000-kw. Westinghouse turbo-generator and three 1800-hp. Bigelow-Hornsby boilers, equipped with Westinghouse stokers. These stokers are 29 ft. wide. Clinker grinders and a hydraulic ash disposal system will handle the refuse of combustion. Steam will be generated at 300 lb. pressure and 150 deg. F. superheat. Economizers and deaerators will be installed.

Individual Sturtevant fans will supply air for combustion and Terry-Janesville turbo-feed pumps will be used.

One interesting feature of the installation will be the use of a closed cooling system for the generator, using an inert gas in order to reduce the fire hazard.

As the old section of the plant operates at a pressure of 200 lb., it will be necessary to tie it in with the 300-lb. boilers through a reducing valve and de-superheater.

Great Western Power Plant to Be Enlarged

MILLIONS will be expended by the Great Western Power Co. during 1923 to increase the generating capacity of its Las Plumas and Caribou plants north of Oroville, Calif. A third unit of the Caribou plant will be installed at a cost of $1,000,000 while expansion of the Las Plumas plant will cost about the same amount.

In order to permit the interchange of electric energy between Caribou transmission lines and the Las Plumas plant, auto transformers will be installed at Las Plumas and at Brighton substation near Sacramento for the purpose of equalizing the voltage between the Caribou line, operating at 165,000 v., and the Las Plumas lines, operating at 110,000 v.

Concerning the installation of a third unit of the Caribou unit, from which San Francisco obtains most of its power, the company announces that the maximum demand in 1922 on the system was 146,000 hp., or about 19,932 hp. greater than the peak of the previous year. The total capacity of the hydroelectric generating equipment is 151,000 hp. and it became apparent late in 1922 that a third unit to increase capacity to 32,000 hp. was essential to meet growing demands.

LOWELL ELECTRIC LIGHT CO., of Lowell, Mass., has awarded contracts to Stone & Webster, Inc., of Boston, Mass., for the construction of an addition to its power house and for the erection of a coal conveyor at its plant on Perry street. The power house addition will be of brick and steel, one story, 63 by 30 ft. The coal conveyor will be of steel, 286 ft. long and 74 ft. at its highest point. The two projects involve an expenditure of $84,000.

Death Closes Career of Captain Robert W. Hunt

ON July 18 death closed the long and active career of Robert W. Hunt, who became widely known through his pioneer work in the development of the steel industry and his constant interest and activity in the advancement of the engineering profession.

Robert W. Hunt

Many honors were awarded Captain Hunt during his life work, the most recent being the Washington Award for the year 1922, which was presented to him by the Western Society of Engineers on the recommendation of the Award Commission made up of representatives of the four founder engineering societies and the Western Society. In 1912 he was given the John Fritz medal.

In 1883 Mr. Hunt was elected president of the American Institute of Mining Engineers, and in 1891 president of the American Society of Mechanical Engineers. In 1896 he was again elected president of the American Institute of Mining Engineers; in 1893, president of the Western Society of Engineers; in 1912, president of the American Society of Testing Materials; and in 1914, American vice-president of the International Association for Testing Materials. At different times he has served on other positions on the boards of all five societies. He was also a member of the American Society of Civil Engineers, the Institute of Civil Engineers, and the Institution of Mechanical Engineers. Mr. Hunt was secretary of the Committee on Standard Rail Sections appointed by the American Society of Civil Engineers, the final report of which was made in 1893, and of the Special Committee on Rail Sections, appointed in 1892, which reported finally in 1910.

Robert Woolston Hunt was born Dec. 9, 1838, in Fallsington, Bucks County, Pennsylvania. His father, Dr. Robert A. Hunt, died in March, 1855, at Covington, Ky. In 1857, he moved with his mother to Pottsville, Pa., where, in the iron rolling-mill of John Burnish & Co., he spent several years acquiring a practical knowledge of puddling, heating, rolling and other details of the iron rail business. In 1859, he took a course of analytical inorganic chemistry in the laboratory of Booth, Garrett & Reese in Philadelphia. In 1860 he was employed as chemist by Wod, Morrell & Co., then lessees of the Cambria Iron Works, at Johnstown, Pa., and established at these works the first analytical laboratory maintained in America by an iron and steel company as a part of its organization.

From this time on until 1888, with the exception of the civil war period in which he served as a captain, Mr. Hunt was actively identified with the steel industry. In 1888 he established the Robert W. Hunt Co., with headquarters in Chicago, and the test, inspection and service work of this organization further enhanced his reputation as an engineer

News Notes

GEO. T. LADD, president of the Geo. T. Ladd Co., Pittsburgh, Pa., has been appointed a member of a subcommittee of the A. S. M. E. on the storage of coal. This committee is part of a large committee recently appointed by the Federated American Engineering Societies and was organized to determine the engineering, mechanical and economic factors involved in the storage of coal and the influence of those factors on storage at the mine by the various classes of consumers. Mr. Ladd represents the Pittsburgh section of the A. S. M. E.

A NEW BLEACHERY and cotton mill is being built for the Pacific Mills at Lyman, S. C., under the supervision of Lockwood, Greene & Co., engineers, of Boston, Mass. The entire plant will be driven electrically by purchased power. A boiler house to supply steam for the bleaching and finishing processes and for heating is included in the development. This boiler plant will be equipped with water-tube boilers, underfeed stokers and auxiliaries. Steam will be supplied to bleachery and mill at boiler pressure and all clean drips will be returned by gravity flow to the open heater in pump room. The project will include also a large water filtration plant and a very complete fire protection system.

STANDARD TURBINE CORP. of Wellsville, N. Y., have purchased the plant of the Charles Youngs Machine Co. in Wellsville, where it is at the present caring for the output. A contract has been awarded to the Austin Co. in Cleveland for the construction of a new steel building at Scio, N. Y., 4 mi. from Wellsville, to be completed in August this year. This will be the permanent location of the plant and the Youngs factory will be used only until the time this new building is completed. After that time the Youngs shop will be used for storage purposes by the company.

DIAMOND POWER SPECIALTY CO., of Detroit, Mich., announces the following appointments in its district offices: Paul E. Theis as sales manager of the Cleveland district with offices at 608 Rockefeller Bldg.; Burford, Hall & Smith, American Trust and Savings Bank Bldg., Birmingham, Ala., district representatives; Boiler Equipment Service Co., Candler Bldg., Atlanta, Ga., as representatives in the states of Georgia and Florida.

E. M. BREED, for several years past assistant manager of sales for the Pelton Water Wheel Co., has been appointed sales manager for the company, with headquarters in San Francisco. Mr. Breed has had a wide experience in hydroelectric work, having been connected with the Pelton Water Wheel Co. in various capacities for the past 15 yr.

GENERAL REFRACTORIES CO. has opened a sales office at 200 Devonshire St., Boston, Mass. Malcolm C. Sargent will be district sales manager in charge of this office.

GREEN EQUIPMENT CORPORATION, of Chicago, manufacturer of commutator undercutting tools, commutator stones and cements, announces the appointment of Thomas H. Endicott as vice-president and general manager. Mr. Endicott is well known in industrial circles because of his former connection with the Crocker-

Wheeler Co., and later as sales manager for the metal cutting department of the E. C. Atkins Co. Recently he organized a company to serve as engineering consultant to industrials, with headquarters in Indianapolis.

STANDARD INSPECTION Co. of Pittsburgh, Pa., announces that it has retained P. J. Freeman as consulting engineer and technical adviser on all of its contracts relating to concrete materials and construction, testing of power plants, pumping machinery, and special investigations.

KROESCHELL BROTHERS Co., the Kroeschell Brothers Ice Machine Co., both of Chicago, Ill., and the Brunswick Refrigerating Co., of New Brunswick, N. J., now operating under the name of Brunswick-Kroeschell Co., is engaged in the erection of new brick and concrete factory buildings to accommodate increasing business. The buildings and equipments are being erected at a cost of approximately $500,000 upon the company's property at Diversey Avenue and the Chicago, Milwaukee & St. Paul right-of-way in Chicago. The much-needed expansion of factory facilities will allow the Brunswick-Kroeschell Co. to meet the increasing demand for their refrigerating machinery, heating and power boilers, separators, chain wrenches, etc. The financial condition of this company is unusually sound, its present assets being over $3,500,000 and the net sales for 1922 more than $2,000,000.

Books and Catalogs

THE ESSENTIALS OF TRANSFORMER PRACTICE, by Emerson G. Reed; first edition, 5½ by 8 in., 266 pages, 124 illustrations, cloth; New York, N. Y., 1923.

A book which discusses the theory of the transformer, the problem of design and questions of operation from a practical engineering point of view. Only those theories are developed, however, which have a direct bearing on design and operation.

The nucleus of the book was a series of lectures to the transformer section of the Electric Club of the Westinghouse Electric and Manufacturing Co., although much of the text is original.

It is a book for engineering students as well as for designing and operating engineers.

PRINCIPLES OF CHEMICAL ENGINEERING by William H. Walker, Warren K. Lewis, and William H. McAdams; 637 pages, 6 by 9 in., cloth, New York, 1923.

Examination of the subject matter of this book reveals that the title is inadequate. It might properly be inferred from the title that it is a book on chemical engineering for chemical engineers. As a matter of fact it treats many topics of particular interest to power plant engineers which are but remotely related to chemical science as it is ordinarily thought of.

The text is divided, in a general way, into five parts: The first deals with fundamental chemical reactions and units involved. The second is a study of the phenomena accompanying the flow of heat and of fluids. It is in reality practically a treatise on thermodynamics. The third section deals with fuels and their economic and efficient combustion. The fourth treats of various processes of crushing and grinding, separation of materials and various filtration processes. The fifth part deals with vaporization processes; drying, humidification, dehumidification, water cooling, evaporation and distillation.

The book as a whole is well written and readily understood, but there are passages where it has been found expedient to resort to more or less complex mathematical treatment, to convey the meaning adequately.

AMERICAN WELDING SOCIETY has just issued an outline of a course for the training of oxy-acetylene welders. This report was prepared by a committee and combines the experience of experts of the Federal Board of Vocational Education, the American Welding Society and the National Research Council. For the information of the person who is selecting candidates, the text includes a discussion of the qualifications which the candidates for training should possess. For the information of the instructor the text includes the fundamentals in gas welding, together with a detailed statement of content, classified under type welding jobs arranged in the order of difficulty. Copies may be secured from the American Welding Society, 29 West 39th St., New York City.

A NEW STYLE of centrifugal pump, called a "series pump," is described in a catalog just issued by the De Laval Steam Turbine Co., Trenton, N. J. In this pump double suction impellers and volute diffusers are used, as in single-stage centrifugal pumps. The connecting passages from stage to stage, however, are included in the pump case casting, as in the ordinary multistage pump. The advantages claimed are perfect hydraulic axial balance and high efficiency under varying loads, as is characteristic of the single stage pump. These series pumps are made with two or three stages. Where more than three stages are required the use of two independent pumps operating in series and mounted on a single base plate is recommended in order to keep down the length of shaft between bearings.

TWO BULLETINS of interest to power plant engineers are being distributed by the Elliott Co., of Jeannette, Pa., one under the title of "Conquer Corrosion" and the other on "Lagonda Filters and Grease Extractors." The bulletin on Corrosion discusses this problem in connection with power plants and pipe in buildings and shows how to protect boilers, economizers and piping by removing the dissolved oxygen in water by the Elliott deaeration process. The process is described and made clear by the use of diagrammatic sketches. In the bulletin on Filters and Grease Extractors, the need for such apparatus is shown and the mechanical details of the Lagonda types of such equipment are described.

PATTERSON hot water service heaters are covered in a new general catalog now being distributed by the Patterson Kelley Co., 101 Park Ave., New York City. This catalog illustrates and describes the full line of Patterson heaters and converters for industrial and domestic services requiring hot water. Tables are also given showing sizes and clearances and also a steam conversion table which may be used in calculating heater sizes.

DETROIT STOKER Co., of Detroit, Mich., has issued a bulletin describing its new level fuel bed, multiple retort underfeed stoker. The features of this stoker are described and applications to various types of boilers and furnaces illustrated.